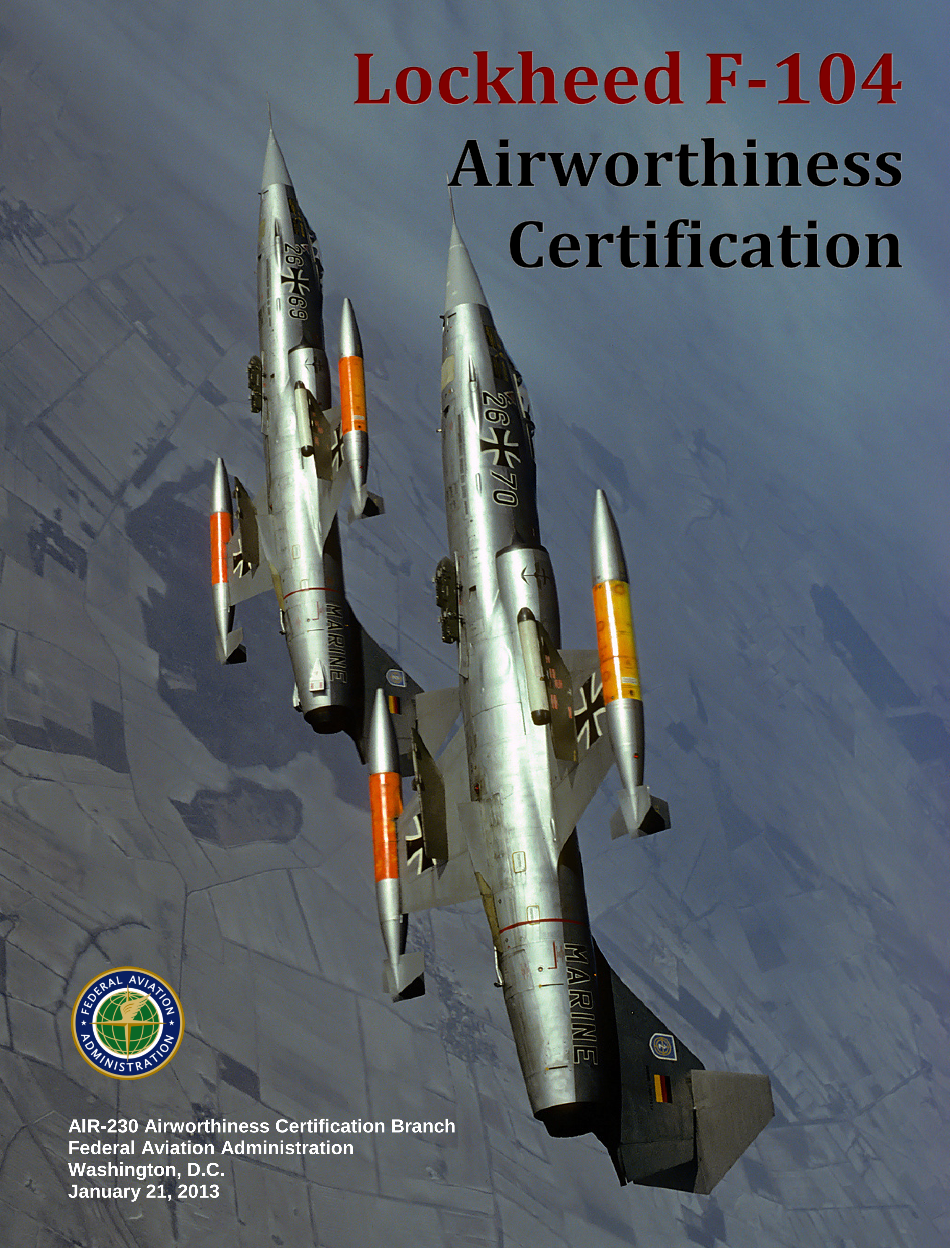
Lockheed F-104

Airworthiness Certification



AIR-230 Airworthiness Certification Branch
Federal Aviation Administration
Washington, D.C.
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Introduction – F-104 Airworthiness Certification

This document provides information to assist in the airworthiness certification and safe civil operation of a Lockheed F-104 aircraft.

Attachment 1 provides a general overview of this document. Attachment 2 contains background information on the F-104 aircraft. Attachment 3 lists historic airworthiness issues with the F-104 for consideration in the certification, operation, and maintenance of these aircraft. The list is not exhaustive, but includes our current understanding of risks that should be assessed during in the certification, operation, and maintenance of these aircraft. Concerns regarding particular issues may be mitigated in various ways. Some may be mitigated via the aircraft maintenance manual(s) or the aircraft inspection program. Others may be mitigated via operating procedures i.e., SOPs) and limitations, aircraft flight manual changes, or logbook entries

Not all issues in attachment 3 may apply to a particular aircraft given variations in aircraft configuration, condition, operating environment, or other factors. Similarly, circumstances with an aircraft may raise other issues not addressed by attachment 2 that require mitigation. Attachment 4 includes additional resources and references. Attachment 5 provides some relevant F-104 accident and incident data. Attachment 6 contains a glossary and a listing of abbreviations.

Attachment 1 – Overview of this Document

Purpose

This document is to provide all those involved in the certification, operation, and maintenance of the Lockheed F-104 aircraft with safety information and guidance to help assess and mitigate safety hazards for the aircraft. The existing certification procedures in FAA Order 8130.2, Airworthiness Certification of Aircraft and Related Products, do not account for many of the known safety concerns and risk factors associated with many high-performance former military aircraft. These safety concerns and risk factors associated with many high performance former military aircraft include—

- Lack of consideration of inherent and known design failures;
- Several single-point failures;
- Lack of consideration for operational experience, including accident data and trends;
- Operations outside the scope of the civil airworthiness certificate;
- Insufficient flight test requirements;
- Unsafe and untested modifications;
- Operations over populated areas (the safety of the non-participating public has not been properly addressed in many cases);
- Operations from unsuitable airports (i.e., short runways, Part 139 (commercial) airports);
- High-risk passenger carrying activities taking place;
- Ejection seat safety and operations not adequately addressed;
- Weak maintenance practices to address low reliability of aircraft systems and engines;
- Insufficient inspection schedules and procedures;
- Limited pilot qualifications, proficiency, and currency;
- Weapon-capable aircraft not being properly demilitarized, resulting in unsafe conditions;
- Accidents and serious incidents not being reported; and
- Inadequate accident investigation data.

Research of F-104 Safety Data

The aircraft, relevant processes, and safety data are thoroughly researched and assessed. This includes—

- Aviation Safety (AVS) Safety Management System (SMS) policy and guidance;
- Historical military accident/incident data and operational history;
- Civil accident data;
- Safety risk factors;
- Interested parties and stakeholders (participating public, non-participating public, associations, service providers, air show performers, flying museums, government service providers, airport owners and operators, many FAA lines of business, and other U.S. Government entities);
- Manufacturing and maintenance implications; and
- Design features of the aircraft.

This Document

The document is a compilation of known safety issues and risk factors identified from the above research that are relevant to civil operations. This document is organized into four major sections:

- General airworthiness issues (grey section),
- Maintenance (yellow section),
- Operations (green section), and
- Standard operating procedures and best practices (blue section).

This document also provides background information on the aircraft and an extensive listing of resources and references.

How to Use the Document

This document was originally drafted as job aids intended to assist FAA field office personnel and operators in the airworthiness certification of these aircraft. As such, some of the phrasing implies guidance to FAA certification personnel. The job aids were intended to be used during the airworthiness certification process to help identify any issues that may hinder the safe certification, maintenance, or operation of the aircraft. The person performing the certification and the applicant would to discuss the items in the job aid, inspect documents/records/aircraft, and mitigate any issues. This information would be used to draft appropriate operating limitations, update the aircraft inspection program, and assist in the formulation of adequate operating procedures. There are also references to requesting information from, or providing information to the person applying for an airworthiness certificate. We are releasing this document as drafted, with no further updates and revisions, for the sole purpose of communicating safety information to those involved in the certification, operation, and maintenance of these aircraft. The identified safety issues and recommended mitigation strategies are clear and can be considered as part of the certification, operation, and maintenance of the air aircraft

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Attachment 2—Background on the Lockheed F-104

The Lockheed F-104 Starfighter is a single-engine, high-performance, supersonic interceptor aircraft originally developed for the United States Air Force (USAF) by Lockheed. One of the Century Series of aircraft, it served with the USAF starting in 1958. The last USAF Starfighters left active service in 1969 but were continued in use with the Puerto Rico Air National Guard until 1975. While the Starfighter continued to fly at Luke Air Force Base (AFB) in Arizona with USAF markings until 1983, these aircraft were actually owned by the German Air Force (Luftwaffe) and operated by both USAF and Luftwaffe instructor pilots to train new German F-104 jet pilots. The F-104 was used as a multi-role combat aircraft by many friendly nations including Germany, Canada, Denmark, Belgium, Norway, Turkey, Greece, Italy, the Netherlands, Spain, Pakistan, Jordan, Japan, and the Republic of China (Taiwan).

An early USAF F-104A in flight. Source: USAF.

Operational service of the Starfighter did not end until May 2004, when the Italian Air Force retired its last F-104s 46 years after the aircraft’s introduction in 1958. The National Aeronautics and Space Administration’s (NASA) Dryden Flight Research Center flew Lockheed F-104 Starfighters in a wide variety of missions beginning in August 1956. Over the next 38 years, 11 were operated by NASA Dryden at Edwards AFB in California, with the last Starfighter flight taking place in February 1994.

The F-104 is unusual in that Lockheed built only slightly more than a quarter of all the airplanes manufactured. The rest were built in seven different countries. Although Messerschmitt was Lockheed’s lead European partner, the European airplanes were actually built by European consortia comprising four major nodes: ARGE Süd (Germany), ARGE Nord (the Netherlands, Germany, and Belgium), the “West Group” (Belgium and Germany), and the “Italian group” (Italy). General Electric (GE) J79 engines for these airplanes were built under license by BMW in Koblenz, West Germany, with some components supplied by FN (*Fabrique Nationale*) in Brussels, Belgium; others were coproduced by MAN in Germany and Fiat in Italy. The European consortium was coordinated by the North Atlantic Treaty Organization (NATO) Starfighter Management Office, also in Koblenz.

Three NASA F-104s in formation in the 1970s. Source: NASA.

In addition, F-104 variants were built by Canadair in Canada (CF-104), with GE J79 engines license-built by Orenda, and by Mitsubishi in Japan (F-104J) with engines license-built by Ishikawajima-Harima. Several variants of the F-104 exist, including the F-104A (fighter-interceptor), F-104B (two-seat trainer), F-104C (fighter-bomber), F-104D (two-seat trainer), F-104G (German fighter-bomber), TF-104G (German trainer), F-104S (Italy), CF-104 (Canada), and F-104J (Japan), as well as several other configurations depending on radar and avionics/navigation systems.

One of the Century Series of aircraft, the Starfighter was the first USAF fighter capable of sustained Mach 2 flight. The USAF deployed the F-104 in Vietnam in 1965 and 1967 in the air superiority and air support missions. Although the aircraft made no air-to-air kills, they flew over 5,200 sorties and were successful in deterring MiG interceptors. Fourteen F-104s were lost to all causes while deployed to Vietnam, four to engine failure. In 1967, the last F-104As in regular USAF service were re-engined with more powerful and reliable J79-GE-19 engines.

Pakistan briefly deployed F-104A aircraft during the Indo-Pakistani wars. Republic of China (Taiwan) Air Force F-104s also engaged the People’s Liberation Army (China) Air Force over the disputed island of Quemoy. The ultimate production version of the basic fighter model F-104 was the F-104S all-weather interceptor, designed by Aeritalia for the Italian Air Force, and equipped with radar-guided AIM-7 Sparrow missiles.

A set of modifications produced the F-104G model, which won a NATO competition for a new fighter-bomber. Several two-seat trainer versions were also produced, the most common being the TF-104G. A total of 2,578 Starfighters were eventually produced, mostly by NATO members. The F-104 served with the air forces of over a dozen nations.

The XF-104 from Lockheed taxis on Rogers Dry Lake, Edwards Air Force Base in the 1950s. The XF-104 is distinguished by the lack of inlet shock cones and the short fuselage. Source: USAF.

The F-104 design was very innovative at the time of its introduction. To achieve the desired performance, Lockheed chose a minimalist approach: a design that would achieve high performance by wrapping the lightest, most aerodynamically efficient airframe possible around a single powerful engine. The engine chosen was the new GE J79, an engine of dramatically improved performance compared to contemporary designs. The small L-246 design powered by a single J79 remained essentially identical to the L-083 Starfighter as eventually delivered. In November 1952, the design was presented to the USAF, which was interested enough to create a General Operating Requirement for a lightweight fighter to replace the North American F-100. Lockheed was granted a development contract in March 1953 for two prototypes; these were given the designation “XF-104.”

Work progressed quickly, with a mockup ready for inspection at the end of April 1953, and work starting on two prototypes in late May. Meanwhile, the J79 engine was not ready; both prototypes were instead designed to use the Wright J65 engine, a license-built version of the Armstrong Siddeley Sapphire.
The first prototype was completed by early 1954 and first flew on March 4 of that year at Edwards AFB. The total time from design to first flight was only about 2 years.

When the USAF revealed the existence of the XF-104, they gave only a vague description, similar to the secret F-117A in the 1980s. Surprisingly, however, artists working for various magazines came up with drawings very close to the actual design, including one in the August 1954 edition of *Popular Mechanics*. The prototype hopped into the air on February 18, 1954, but this was not counted as a first flight, and on the first official flight, the airplane experienced landing gear retraction problems. The second prototype was destroyed a few weeks later during gun-firing trials, but in November 1955 the prototype was accepted by the USAF. The J65 with afterburner did not allow the aircraft to reach its design speed. Directional stability issues needed to be corrected and additional fuel carried.

A USAF NF-104 ready for a high-altitude flight in 1963. Source: USAF.

The F-104 featured a radical wing design. Most jet fighters of the period used a swept-wing or delta-wing plan form. This allowed a reasonable balance between aerodynamic performance, lift, and internal space for fuel and equipment. Lockheed's tests, however, determined the most efficient shape for high-speed, supersonic flight was a very small, straight, mid-mounted, trapezoidal wing. The new wing design was extremely thin, with a thickness-to-chord ratio of only 3.36 percent and an aspect ratio of 2.45. The wing's leading edges were so thin (0.016 in/0.41 mm) and sharp that they presented a hazard to ground crews, and protective guards had to be installed during ground operations. The thinness of the wings required fuel tanks and landing gear to be placed in the fuselage.

The hydraulic cylinders driving the ailerons had to be only 1 inch (25 mm) thick to fit. The wings had both leading-edge and trailing-edge flaps. The small, highly-loaded wing resulted in an unacceptably high landing speed, so a boundary layer control system (BLCS) of blown flaps was incorporated, bleeding engine air over the trailing-edge flaps to energize airflow and thus improve lift. The system was a boon to safe landings, although it proved to be a maintenance problem in service, and landing without the BLCS could be a harrowing experience.

The stabilator (horizontal tail surface) was mounted atop the fin to reduce inertia coupling. Because the vertical fin was only slightly shorter than the length of each wing and nearly as aerodynamically effective, it could act as a wing on rudder application (a phenomenon known as “Dutch roll”). To offset this effect, the wings were canted downward, at a 10 degrees anhedral angle.

The Starfighter’s fuselage had a high fineness ratio (that is, it was slender, tapering toward the sharp nose) and a small frontal area. The fuselage was tightly packed, containing the radar, cockpit, cannon, fuel, landing gear, and engine. This fuselage and wing combination provided extremely low drag except at high angle of attack (AOA), at which point induced drag became very high. As a result, the Starfighter had excellent acceleration, rate of climb, and potential top speed, but its sustained turn performance was poor. A later modification on the F-104A/B allowed use of the takeoff flap setting to Mach 1.8 (550 knots), which materially improved maneuverability. The aircraft was sensitive to control input, and extremely unforgiving to pilot error.

Japanese Self Defense Air Force (JASDF) F-104J photographed in the 1980s. Source: www.defenseimagery.mil.

The F-104 was designed to use the GE J79 turbojet engine, fed by side-mounted intakes with fixed inlet cones optimized for supersonic speeds. Unlike some supersonic aircraft, the F-104 did not have variable-geometry inlets. Its thrust-to-drag ratio was excellent, allowing a maximum speed well in excess of Mach 2; the top speed of the Starfighter was limited more by the aluminum airframe structure and the temperature limits of the engine compressor than by thrust or drag (which gave an aerodynamic maximum speed of Mach 2.2). Later models used improved versions of the J79, improving both thrust and fuel consumption significantly.

A front view of an F-104G loaded with bombs on all stations. Note the thin wing. Source: USAF.

Early Starfighters used a downward-firing ejection seat (the Stanley C-1), out of concern over the ability of an upward-firing seat to clear the "T-tail" empennage. This presented obvious problems in low-altitude escapes, and approximately 21 USAF pilots failed to escape their stricken aircraft in low-level emergencies because of it. The downward-firing seat was soon replaced by the Lockheed C-2 upward-firing seat, which was capable of clearing the tail, although it still had a minimum speed limitation of 104 mph (170 km/h). Many export Starfighters were later retrofitted with Martin-Baker Mk.7 zero-zero ejection seats, which had the ability to successfully eject the pilot from the aircraft even at zero altitude and zero airspeed. The initial USAF Starfighters had a basic AN/ASG-14T ranging radar, tactical air navigation system (TACAN), and an AN/ARC-34 UHF radio. The later international fighter-bomber aircraft had a much more advanced Autonetics NASARR radar, an advanced Litton LN-3 Inertial Navigation System (INS), a simple infrared sight, and an air data computer.

In the late 1960s, Lockheed developed a more advanced version of the Starfighter, the F-104S, for use by the Italian Air Force as an all-weather interceptor. The F-104S received a NASARR R21-G with a moving-target indicator and a continuous-wave illuminator for semi-active radar homing missiles, including the AIM-7 Sparrow and Selenia Aspide. The missile-guidance avionics forced the deletion of the Starfighter's internal cannon. In the mid-1980s, surviving F-104S aircraft were updated to ASA standard (*Aggiornamento Sistemi d'Arma*, or Weapon Systems Update), with a much-improved, more compact R21G/M1 radar.

The basic armament of the F-104 was the 20 mm M61 Vulcan Gatling gun. The Starfighter was the first aircraft to carry the new weapon, which had a rate of fire of 6,000 rounds per minute. The cannon, mounted in the lower part of the port fuselage, was fed by a 725-round drum behind the pilot's seat. It was omitted in all two-seat models and some single-seat versions, including reconnaissance aircraft and the early Italian F-104S; the gun bay and ammunition tank were usually replaced by additional fuel tanks. Two AIM-9 Sidewinder air-to-air missiles could be carried on the wingtip stations, which could also be used for fuel tanks. The F-104C and later models added a centerline pylon and two under wing pylons for bombs, rocket pods, or fuel tanks. The centerline pylon could carry a nuclear weapon; a "catamaran" launcher for two additional Sidewinders could be fitted under the forward fuselage, although the installation had minimal ground clearance and made the seeker heads of the missiles vulnerable to ground debris. The F-104S models added a pair of fuselage pylons beneath the intakes available for conventional bomb carriage. The F-104S had an additional pylon under each wing, for a total of nine pylons.

A total of 2,575 F-104s were produced by Lockheed and under license by various foreign manufacturers. Of these, it is estimated that at least 800, or 31% were lost in accidents. The safety record of the F-104 Starfighter became high-profile news, especially in Germany, in the mid-1960s. In West Germany, the aircraft came to be nicknamed *Witwenmacher* ("The Widowmaker.") Some operators lost a large proportion of their aircraft through accidents, although the accident rate varied widely depending on the user and operating conditions. The German Air Force lost about 30 percent of aircraft in accidents over its operating career. During 30 years of operations in Germany, the total hours flown by the F-104 reached 1,975,646. A total of 296 F-104s were lost in accidents, and German Air Force losses totaled 116 pilots. This amounts to an accident rate of 14.8 per 100,000 hours, but does not include accidents (Class A mishaps) where the aircraft was not destroyed. At the height of the crisis, the Starfighter accident rate peaked at 139 per 100,000 flying hours and in fact, between 15 and 20 Starfighters crashed very year between 1968 and 1972. Crashes continued at a rate of 9 to 11 aircraft per year until the early 1980s, when all German F-104Gs began to be replaced by Tornados.

The introduction of a highly technical aircraft type to the newly reformed German Air Force was fraught with problems. Many pilots and ground crew had settled into civilian jobs after World War II and had not kept pace with developments, with pilots being sent on short "refresher" courses in slow and benign-handling first generation jet aircraft. Ground crews were similarly employed with minimal training and experience, which were the consequence of a conscripted military with high turnover of servicemen.

Operating in poor northwest European weather conditions (vastly unlike the fair weather training conditions at Luke AFB in Arizona) and flying at high speed and low level over hilly terrain, many accidents were attributed to controlled flight into terrain or water (CFIT). Also, a contributing factor was the operational assignment of the F-104 in German service; it was mainly intended for use as a fighter-bomber use, as opposed to the original design of a high-speed, high-altitude fighter/interceptor. This not only meant providing for the usual low-level missions, but also led to the installation of additional avionic equipment in the F-104G version, such as the INS, the additional weight of which hampered the flying abilities of the plane even further and was said to add far more distraction to the pilot. In contemporary German magazine articles highlighting the Starfighter safety problems, the aircraft was portrayed as "overburdened" with technology, which was considered a latent overstrain on the aircrews. The number of engineering problems ranged from engine failures, open nozzles (exhaust) oxygen malfunctions, drag chute and landing gear actuator failures, to extreme nose wheel shimmies and malfunctions of the Automatic Pitch Control (APC) system. The F-104s were frequently grounded to undergo special inspections or modifications.

In 1966 Johannes Steinhoff took over command of the Luftwaffe and grounded the entire F-104 fleet until he was satisfied that problems had been resolved or at least reduced. Erich Hartmann, the world's top-scoring fighter ace, commanded one of Germany's first jet fighter-equipped squadrons and deemed the F-104 an unsafe aircraft with poor handling characteristics for aerial combat. In later years, the

German safety record improved, although a new problem of structural failure of the wings emerged. Original fatigue calculations had not taken into account the high number of G-force loading cycles the German F-104 fleet was experiencing, and many airframes were returned for depot maintenance where their wings were replaced, while other aircraft were simply retired.

A 1982 view of an F-104 Starfighter aircraft in flight during training exercise Cope North '83-1. Note the TDU-10 Dart Gunnery Target System on the left wing. The F-104 belongs to a unit of the Japanese Air Self Defense Force stationed at Chitose Air Base. Source: www.defenseimagery.mil.

Other operators F-104 accident histories are also relevant. For example, Canada lost over 50 percent of its F-104s (110 CF-104 and CF-104D models out of 239 delivered), with an estimated accident rate of about 24 per 100,000 hours, based on 450,000 hours. In all the Belgian Air Force lost 41 Starfighters for an attrition rate of 41%, high by any standard. The accident rate of the Italian Air Force single-seat F/RF-104Gs and two-seat TF-104Gs was fairly high, with about 37.5 percent of the force having been lost. Between January 1964 and March 1976 the Italian Air Force lost 73 Starfighters, a figure which rose to 138 machines at the beginning of 1992 out of a total or 368 delivered in 928,000 flying hours (14.7 aircraft every 100,000 hours). This accident rate was similar to the overall German accident rate.

The Dutch Air Force safety record with the F-104 was 12.5 per 100,000 hours, a marked improvement despite having lost 46 aircraft in accidents out of 138 aircraft received, for an attrition rate of 33%. This was due largely to pilot requirements (500 hours of F-5 flight time) before assignment to F-104 units. The Danish Air Force lost 12 out of 51 received, for an attrition arte of 23%. The Norwegian Air Force lost 6 of its 43 F-104s for an enviable attrition rate of 13%. Even better, the Spanish Air Force, which operated the aircraft from 1966 until 1972 for a total of 16,000 hours, lost none, although there were accidents that would be qualified as Class A mishaps. The Spanish Air Force record is also credited to high pilot experience requirements, namely 1,000 hours of high-performance jet time (some sources cite 500 hours) before an F-104 assignment.

Although the Turkish Air Force obtained 433 F-104s, at least 110 were lost in crashes (25% attrition rate), its operational philosophy is noteworthy. In Turkish Air Force service, the F-104 was notoriously known as an unforgiving and difficult aircraft. The Turkish Air Force decided to post only seasoned pilots to the F-104 squadrons. To be eligible to fly the F-104, a pilot had to complete two combat readiness periods with frontline squadrons. Most pilots recruited to the F-104G had already logged 1,000+ hours on other combat aircraft types, including the F-100. Consequently, the F104 squadrons were manned by crème de la crème of the Turkish Air Force in the early Starfighter days.

By contrast, the Class A mishap rate of the F-104 in USAF service was higher, at 26.7 accidents per 100,000 flight hours as of June 1977, the highest accident rate of any USAF Century Series fighter. It had been worse earlier. By the time the F-104 had logged its 100,000th flight hour, in April 1961, 49 out of 296 Starfighters operated by the USAF had been lost. For comparison purposes, the Class A mishap rate of the USAF F-16 Falcon from 1975 to 1993 was 5.09 per 100,000 flight hours; from 1982 to 2000, it declined to 4.5. The F/A-18 Hornet C/D models have a lifetime rate of 3.45 per 100,000 hours, and the F-15 Eagle has a rate of 2.4.

Notable USAF pilots who lost their lives in F-104 accidents include Brig. Gen. Barnie B. McEntire, Lt. Col. Raymond A. Evans, Maj. Henry J. Schneckloth, Maj. Robert H. Lawrence, Jr. and Capt. Ivan Kincheloe. Civilian (former USAF) pilot Joe Walker died in a midair collision with an XB-70 Valkyrie while flying an F-104. Chuck Yeager was nearly killed when he lost control of an NF-104A during a high-altitude record-breaking attempt.

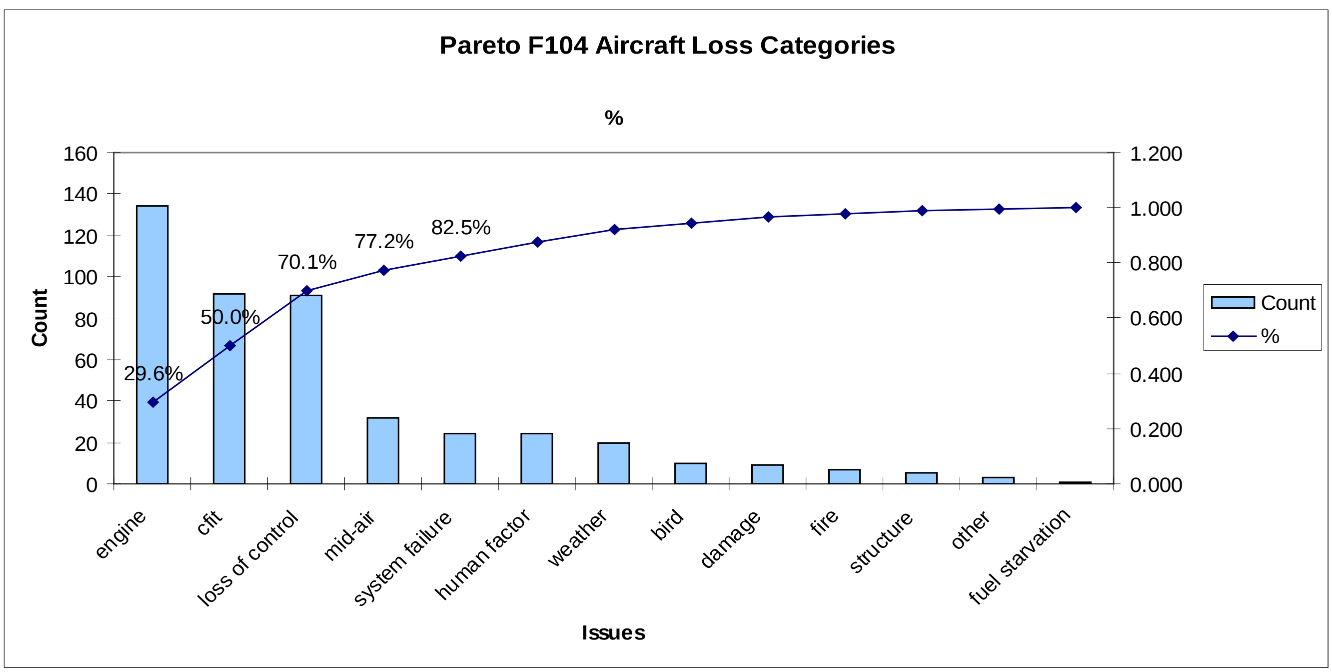
The F-104 series all had a very high wing loading (made even higher when carrying external stores), which demanded sufficient airspeed be maintained at all times. For comparison purposes, the F-86 has a wing loading or 49.4 lb/ft^2 while the F-104 has a wing loading of 105 lb/ft^2. The high AOA area of flight was protected by a stick shaker system to warn the pilot of an approaching stall, and if this was ignored a stick pusher system would pitch the aircraft's nose down to a safer AOA; this was often overridden by the pilot despite flight manual warnings against this practice. At extremely high AOA, the F-104 was known to "pitch-up" and enter a spin, which in most cases was impossible to recover from. The Starfighter had excellent acceleration, rate of climb and top speed, but its sustained turn performance was poor. It was sensitive to control input, and extremely unforgiving to pilot error.

N104RB, a civil Ex-RCAF CF-104D at the 1998 NAS Atlanta air show. The company, Starfighters, Inc. still exists. Source: Frank Mirande. Copyright © 1998. www.airliners.net. Below, a NASA F-104 in the 1980s. Source: NASA.

The J79 was a new engine that continued to be developed during the YF-104A test phase and in service with the F-104A. The engine featured variable incidence compressor stator blades, a design feature that altered the angle of the stator blades automatically with altitude and temperature. A condition known as “T-2 reset,” a normal function that made large stator blade angle changes, caused several engine failures on takeoff. It was discovered that large and sudden temperature changes (from being parked in the sun before getting airborne) were falsely causing the engine stator blades to close and choke the compressor. The dangers presented by these engine failures were compounded by the downward ejection seat, which gave the pilot little chance of a safe exit at low level. The engine systems were subsequently modified and the ejection seat changed to the more conventional upward type. Uncontrolled tip-tank oscillations sheared one wing off of an F-104B; this problem was apparent during testing of the XF-104 prototype and was eventually resolved by filling the tank compartments in a specific order.

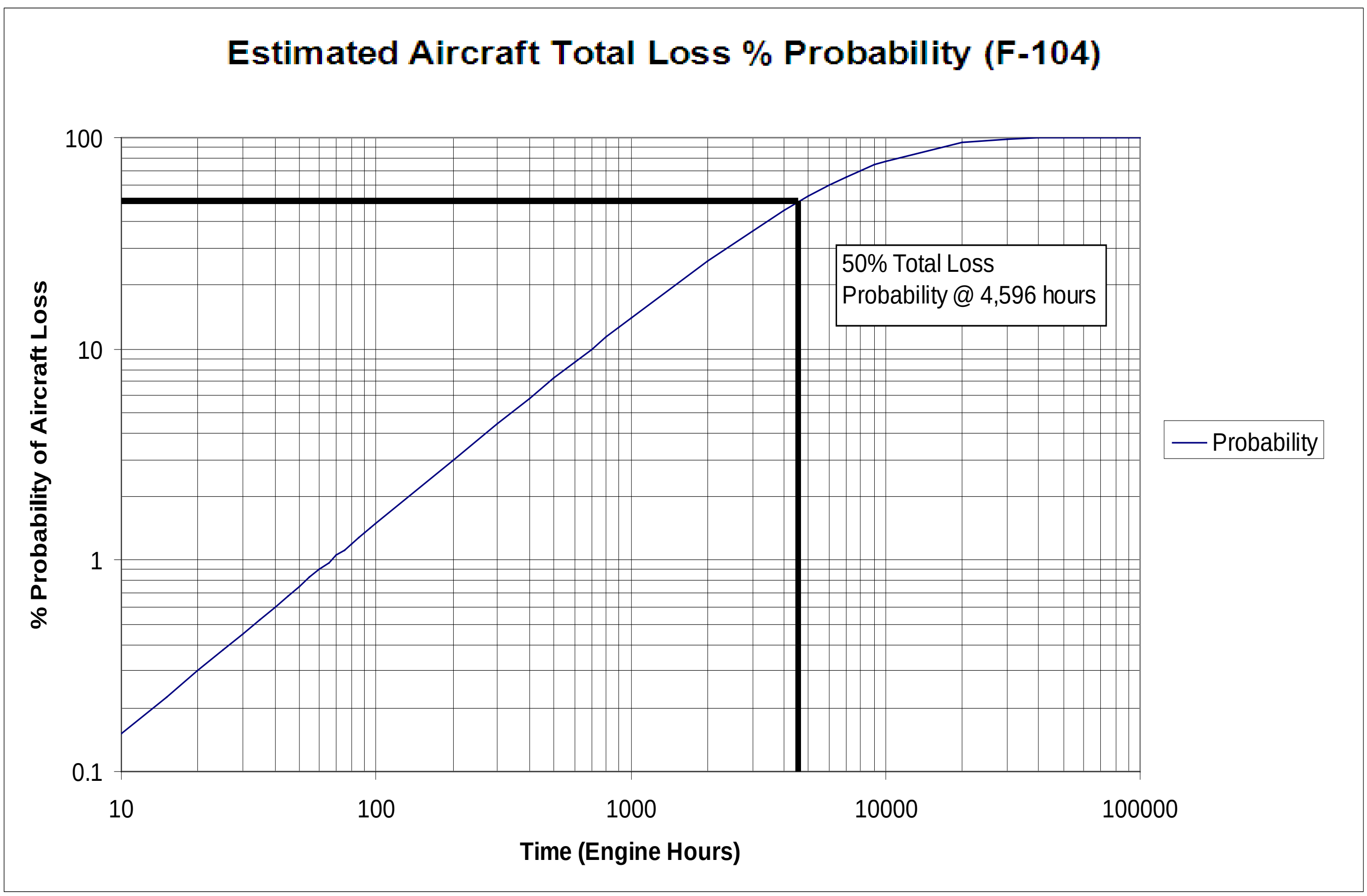
A further engine problem was that of un-commanded opening of the variable thrust nozzle (usually through loss of engine oil); although the engine would be running normally at high power, the opening of the nozzle resulted in a drastic loss of thrust. A modification program installed a manual nozzle closure control, which reduced the problem. The engine was also known to suffer from afterburner blowout on takeoff or even non-ignition resulting in a major loss of thrust, which could be detected by the pilot; the recommended action was to abandon the takeoff. This caused the first fatal accident in German service. Asymmetric flap deployment was another common cause of accidents, as was a persistent problem with severe nose wheel “shimmy” on landing, which usually resulted in the aircraft leaving the runway and, in some cases, even flipping over onto its back.

In summary, the F-104 did not forgive mistakes by inexperienced pilots, and even those with experience had to stay alert and show superior airmanship. In addition, top-notch maintenance and operational procedures are the only way to mitigate many of the safety issues and risk factors with this unforgiving aircraft. This cannot be ignored as part of any civil operation, and thus as part of the airworthiness certification process.



This Pareto graph provides categorizes 452 F-104 accidents (Luftwaffe and Italian Air Force). Although there would variations in any such graph due to the way the data is assigned or categories chosen, (i.e., human error being defined as piloting error rather than encompassing all human errors, including ground crew errors), it provides some insight into some of the categories, namely engine failure and LOC (loss of control). Source: FAA.

Luftwaffe (German Air Force) F-104 Accident Assessment List and Accident Rate February 1962 – May 1991												
Wing/unit timeframe	Timeframe used	Years Ops	Flt Hrs	Human factor	Nozzle/ engine	Aircraft system	Bird strike	Main / ground	FOD / other	Total Losses	Fatal	Rate
JaboG 31B	Feb 62 - May 83	21	211412	16	16	4	5		1	42	14	18.9
JaboG 32B	Jan 65 - Apr 84	19	204986	10	2	2	2			16	6	7.8
JaboG 33	Aug 62 - May 85	22	231900	3	10	4	5		1	22	3	9.5
JaboG 34	Jul 64 - Oct 87	24	242785	17	7	4	1		4	33	11	12.4
JaboG 316	Feb 65 - Jan 75	10	82722	2	4	4		1		11	6	12.1
JG 71 R	Apr 63 - Sep 74	12	83182	12	3	1				17	8	19.2
JG 74	May 64 – Jul 74	11	81840	2	4		1	1	1	9	3	9.8
AG 51	Nov 63 – Apr 71	8	61390	7	3	2	1	2		15	6	22.8
AG 52	Nov 64 – Sep 71	7	55571		1		2			3	1	5.3
MFG 1	Sep 63 – Oct 81	17	131915	9	6		1		2	18	9	14.4
MFG 2	Mar 65 – Sep 86	22	173070	15	3	3	10	1		32	14	17.3
WaSLw 10	May 60 – Sep 83	23	123728	13	5	5				23	12	17.8
2. DtlsAusb	Feb 64 – Mar 83	20	269750	19	8	13			3	43	21	15.6
ErpSt/WTD61	Feb 65 - May 91	23	10500			1				1		0.1
LVR1	May 84 – Sep 88	5	9895						1	1		0.1
MBB/Deci	1962 – 1991			3	4	2		1	2	12	2	
Total			**1,975,646**	**128**	**76**	**45**	**28**	**6**	**15**	**298**	**116**	**14.3**



This table (top) and graph (above) are presented to illustrate an analysis of the Lockheed F-104 accidents incurred by the Luftwaffe (German Air Force) between 1962 and 1991. The table provides insight into several data elements, including year of operation, number of hours, failure type and accident rate. The graph provides an illustration of the probability of an F-104 loss. Source: http://www.916-starfighter.de and FAA.

Investigators pore over the site of the nose-first, high-impact JF-104A crash that left this large crater in the desert near Edwards Air Force Base in December 1962. NASA test pilot Milton O. Thompson ejected from this aircraft on Dec. 20, 1962, after an asymmetrical flap condition made the jet uncontrollable. Source: NASA. Below, a view of the crash of a Luftwaffe F-104G. It crashed on May 17, 1966 at RAF Gutersloh after an emergency landing with open nozzle. It landed with a tail wind, and failed to engage the barrier. The landing gear was ripped, the pilot was injured, and it was struck off charge on June 15, 1966. Source: http://www.916-starfighter.de.

August 18, 1964. A Belgian Air Force F-104 crashes during a low level demonstration. The aircraft crashed onto a hangar. The pilot was killed, Kapt.vl. Pierre Tonet, while several aircraft were destroyed in the hangar. This accident was a clear indication of the F-104's flight characteristics, which cannot be under estimated. Source: http://aviation-safety.net/wikibase/wiki.php?id=47170.

Source: USAF.

The remains of N104RB, the "Red Baron" F-104 after the 1977 accident. Source David Lednicer. Copyright © 2013.

F-104 Production Summary

Type	Lockheed	Multi-national	Canadair	Fiat	Fokker	MBB	Messerschmitt	Mitsubishi	SABCA	Total
XF-104	2									2
YF-104A	17									17
F-104A	153									153
F-104B	26									26
F-104C	77									77
F-104D	21									21
F-104DJ	20									20
CF-104			200							200
CF-104D	38									38
F-104F	30									30
F-104G	139		140	164	231	50	210		188	1122
RF-104G	40			35	119					194
TF-104G (583C to F)	172	27								199
TF-104G (583G and H)		21								21
F-104J	3							207		210
F-104S				245						245
Total by Manufacturer	**738**	**48**	**340**	**444**	**350**	**50**	**210**	**207**	**188**	**2,575**

USAF F-104C belonging to the USAF Museum. Source: USAF.

Specifications (F-104G)

General Characteristics

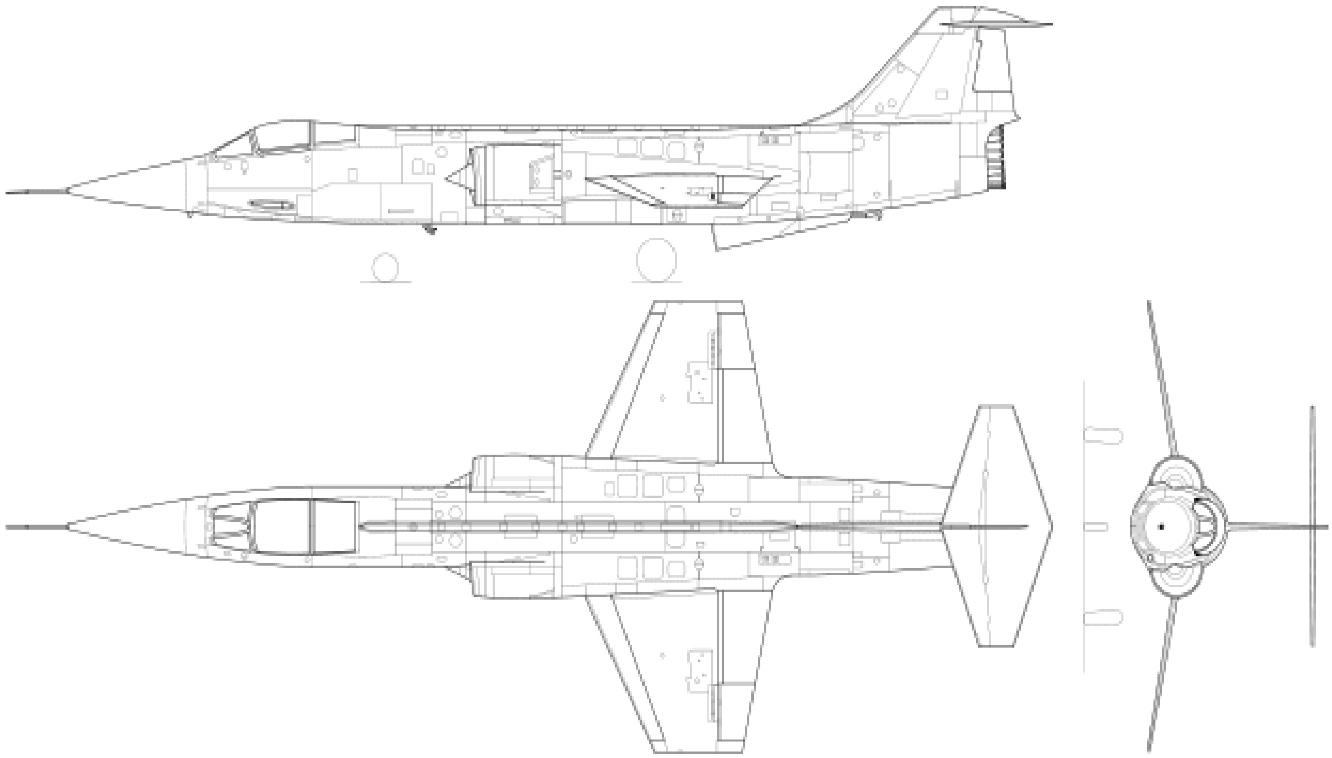
- Crew: One
- Length: 54 ft 8 in (16.66 m)
- Wingspan: 21 ft 9 in (6.36 m)
- Height: 13 ft 6 in (4.09 m)
- Wing area: 196.1 ft² (18.22 m²)
- Airfoil: Biconvex 3.36 percent root and tip
- Empty weight: 14,000 lb (6,350 kg)
- Loaded weight: 20,640 lb (9,365 kg)
- Maximum takeoff weight: 29,027 lb (13,170 kg)
- Powerplant: 1 × General Electric J79-GE-11A afterburning turbojet
    - Dry thrust: 10,000 lb. (48 kn)
    - Thrust with afterburner: 15,600 lb. (69 kn)
-
- Zero-lift drag coefficient: 0.0172
- Drag area: 3.37 sq ft (0.31 m²)
- Aspect ratio: 2.45

Performance

- Maximum speed: 1,328 mph (1,154 knots, 2,125 km/h)
- Combat radius: 420 mi (365 nmi, 670 km)
- Ferry range: 1,630 mi (1,420 nm, 2,623 km)
- Service ceiling: 50,000 ft (15,000 m)
- Rate of climb: 48,000 ft/min (244 m/s)
- Wing loading: 105 lb/ft² (514 kg/m²)
- Thrust/weight: 0.54 with maximum takeoff weight (0.76 loaded)
- Lift-to-drag ratio: 9.2

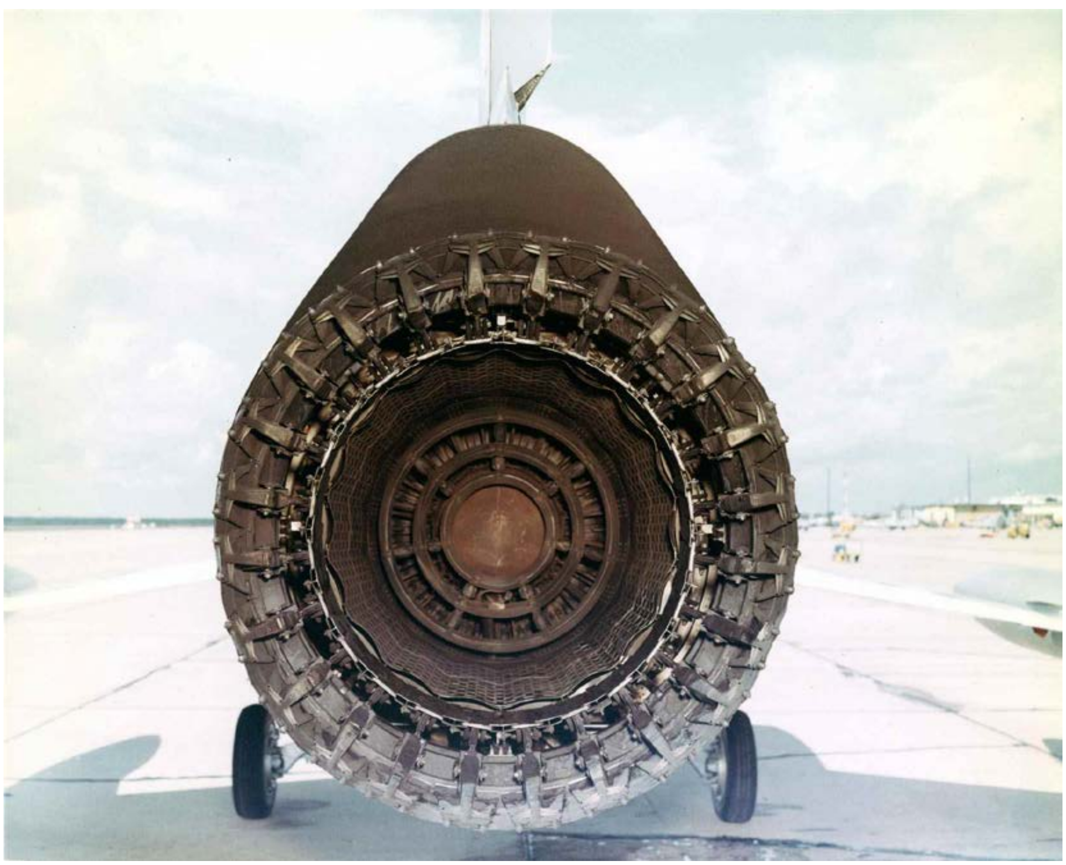
Armament

- Guns: 1 × 20 mm (0.787 in) T171 Vulcan 6-barreled Gatling cannon, 725 rounds
- Hardpoints: 7 with a capacity of 4,000 lb (1,814 kg) and provisions to carry combinations of—
    - Missiles: 4 × AIM-9 Sidewinder
    - Other: Bombs, rockets, or other stores



Source: Kaboldy, http://en.wikipedia.org/wiki/File:Lockheed_F-104C_Starfighter.svg.

F-104 Technical Data & Systems (Web Links)
Courtesy of http://www.916-starfighter.de.
F-104 cutaway (Flight magazine October 1961)
F-104 cutaway (Air International special supplement)
F-104 System and operation: Bad Ass Airplane (general description)
General System information by Theo Stoelinga
Engine System by Theo Stoelinga
J-79 engine animation from the Neumann Museum website of Josef Voggenreiter
Engine Auxiliary Inlet Door system of the F-104S, by Theo Stoelinga
Flight controls by Theo Stoelinga
Bleed Air Supply by Stoelinga
Hydraulic System © http://web.tiscali.it/F104-Starfighter
Utility Hydraulic System © http://web.tiscali.it/F104-Starfighter
LN-3 Navigation system by Theo Stoelinga
TF-104G/F-104F Two Seater by Theo Stoelinga
Electronic Systems by Theo Stoelinga
BLC-Boundary Layer Control (Flight Controls) by Hubert Peitzmeier
Vulcan M61 machine gun © http://en.wikipedia.org/wiki/M61_Vulcan
Ejection Seats of the F-104 select: Stanley/Lockheed/MB: All F-104
Engine T-2 reset by Mike Vivian, USAF F-104 pilot, Luke IP and Luftwaffe Exchange pilot
Engine B-Flaps by Walt BJ, retired USAF F-86, F102, F-104 and F-4 pilot
F-104 versions Technical data (DASA booklet)
Chaff/Flare Dispenser F-104G by Hubert Peitzmeier
NF-104A AeroSpace Trainer (AST) the history of the NF-104A, copyright John Terry White 2005



F-104 Versions and Variants

XF-104

Two prototype aircraft were equipped with Wright J65 engines (the J79 was not yet ready); one of the aircraft was equipped with the M61 cannon as an armament test bed. Both aircraft were destroyed in crashes.

YF-104A

Seventeen preproduction aircraft were used for engine, equipment, and flight testing. Most were later converted to the F-104A standard.

F-104A

A total of 153 initial production versions were built. The F-104A was in USAF service from 1958 through 1960, and then transferred to the Air National Guard until 1963, when they were recalled by the USAF Air Defense Command for the 319th and 331st Fighter Interceptor Squadrons. Some were released for export to Jordan, Pakistan, and Taiwan, each of which used the aircraft in combat. In 1967 the 319th F-104As and Bs were re-engined with the J79-GE-19 engines with 17,900 lb of thrust in afterburner; the service ceiling with this engine was in excess of 73,000 ft (22,250 m). In 1969, all the F-104A/Bs in Air Defense Command service were retired. On May 18, 1958, an F-104A set a world speed record of 1,404.19 mph (2,259.82 km/h).

NF-104A

Three demilitarized versions with an additional 6,000 lb Rocketdyne LR121/AR-2-NA-1 rocket engine were built, used for astronaut training at altitudes up to 120,800 ft (36,820 m).

QF-104A

A total of 22 F-104As were converted into radio-controlled drones and test aircraft.

F-104B

Twenty-six tandem two-seat, dual-control trainer versions of F-104A were built. They featured enlarged rudders and ventral fins, no cannons, and reduced internal fuel, but were otherwise combat-capable. A few were supplied to Jordan, Pakistan, and Taiwan.

F-104C

Seventy-seven fighter-bomber versions were built for USAF Tactical Air Command, with improved fire-control radar (AN/ASG-14T-2), centerline and two wing pylons (for a total of five), and ability to carry one Mk 28 or Mk 43 nuclear weapon on the centerline pylon. The F-104C also had in-flight refueling capability. On December 14, 1959, an F-104C set a world altitude record of 103,395 ft (31,515 m).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U.S. AIR FORCE

F-104D

Twenty-one dual-control trainer versions of F-104C were built.

F-104DJ

Twenty dual-control trainer version of F-104J for Japanese Air Self-Defense Force were built by Lockheed and assembled by Mitsubishi.

F-104F

Thirty dual-control trainers based on F-104D, but using the upgraded engine of the F-104G, were built. They had no radar, and were not combat-capable. They were produced as interim trainers for the German Air Force. All F-104F aircraft were retired by 1971.

F-104G

Lockheed produced 1,122 aircraft of the main version as multi-role fighter-bombers. The aircraft were under license by Canadair and a consortium of European companies including Messerschmitt/MBB, Dornier, Fiat, Fokker, and SABCA. The type featured strengthened fuselage and wing structure, increased internal fuel capacity, an enlarged vertical fin, strengthened landing gear with larger tires, and revised flaps for improved combat maneuvering. Upgraded avionics included a new F-15A-41B radar with air-to-air and ground mapping modes, the Litton LN-3 INS (the first on a production fighter) and an infrared sight.

RF-104G

One hundred eighty-nine tactical reconnaissance models based on the F-104G were built, usually with three KS-67A cameras mounted in the forward fuselage in place of a cannon.

TF-104G

Two hundred twenty combat-capable trainer versions of the F-104G were built, with no cannon or centerline pylon, and reduced internal fuel. One aircraft used by Lockheed as a demonstrator with the civil registration number L104L was flown by Jackie Cochran to set three women's world speed records in 1964. This aircraft later served in the Netherlands. A pair of two-seat TF-104Gs and a single-seat F-104G joined the Dryden inventory in June 1975.

F-104H

This aircraft was a projected export version based on a F-104G with simplified equipment and optical gunsight, but was not built.

F-104J

This specialized interceptor version of the F-104G for the Japan Air Self-Defense Force was built under license by Mitsubishi for the air-superiority fighter role, armed with cannon and four Sidewinders. It had no strike capability. Some were converted to UF-104J radio-controlled target drones and destroyed. A total of 210 were built, 3 by Lockheed, 29 by Mitsubishi from Lockheed-built components, and 178 by Mitsubishi.

F-104N

Three F-104Gs were delivered to NASA in 1963 for use as high-speed chase aircraft. One, piloted by Joe Walker, collided with an XB-70 on June 8, 1966.

F-104S

Fiat produced 246 Italian versions (one aircraft crashed before delivery and is often not included in the total number built). Forty aircraft were delivered to the Turkish Air Force and the rest to the Italian Air Force. The F-104S was upgraded for the interception role with the following components: a North American Search and Ranging Radar R-21G/H radar with moving-target indicator and continuous-wave illuminator for semi-active radar homing missiles (initially AIM-7 Sparrow), two additional wing and two underbelly hard points (increasing the total to nine), a more powerful J79-GE-19 engine with 11,870 lb. (53 kN) and 17,900 lb. (80 kN) thrust, and two additional ventral fins to increase stability. The M61 cannon was sacrificed to make room for the missile avionics in the interceptor version but retained for the fighter-bomber variants.

Up to two AIM-7 Sparrows; and two Sidewinder missiles were carried on all the hard-points except the central (underbelly), or seven 750 lb (340 kg) bombs. The F-104S was cleared for a higher maximum takeoff weight, allowing it to carry up to 7,500 lb (3,400 kg) of stores; other Starfighters had a maximum external load of 4,000 lb (1,814 kg). Its range was up to 780 mi (1,250 km) with four tanks.

F-104S-ASA

(*Aggiornamento Sistemi d'Arma* - "Weapon Systems Update") One hundred fifty F-104Ss were upgraded with Fiat R21G/M1 radar with frequency hopping, look-down/shoot-down capability, new "identification, friend or foe" system and weapon delivery computer, and provision for AIM-9L all-aspect Sidewinder and Selenia Aspide missiles. It was first flown in 1985.

F-104S-ASA/M

(*Aggiornamento Sistemi d'Arma/Modificato* - "Weapon Systems Update/Modified") Forty-nine airframes were upgraded in 1998 to the ASA/M standard with a Global Positioning System, new TACAN and Litton LN-30A2 INS, refurbished airframe, and improved cockpit displays. All strike-related equipment was removed. The last Starfighters in combat service, they were withdrawn in December 2004 and temporarily replaced by the F-16 Fighting Falcon, while awaiting Eurofighter Typhoon deliveries.

CF-104

Canadair built 200 versions under license, optimized for both nuclear strike and two-stage-to-orbit payload delivery, having R-24A radar with air-to-air modes, cannon deleted (restored after 1972), additional internal fuel cell, and Canadian J79-OEL-7 engines with 10,000 lb/15,800 lb.

CF-104D

Lockheed built 38 dual-control trainer versions of the CF-104, but with Canadian J79-OEL-7 engines. Some were later transferred to Denmark, Norway, and Turkey.

Foreign Military F-104 Operators

Belgium

Belgium operated F-104Gs and TF-104Gs. They served with four squadrons: 23 and 31 (fighter-bombers), 349 and 350 (interceptors), and finally an operational conversion unit. In total, 101 SABCA-built F-104Gs and 12 Lockheed-built TF-104Gs were purchased (one F-104G crashed before delivery). The Belgian Air Force operated the type from February 14, 1963, to September 19, 1983; some survivors were sent to Taiwan (23 aircraft) and Turkey (18 aircraft). Thirty-eight F-104Gs and three TF-104Gs were lost in accidents.

Canada

The Royal Canadian Air Force, and later the unified Canadian Forces, operated 200 Canadian-built CF-104s and 38 dual-control trainer CF-104Ds (built by Lockheed) between 1962 and 1986. The CF-104s were equipped with additional electronic equipment, with a radar warning receiver function, in the tail and under the nose. Losses were high, with around 110 crashes in Europe. Its heavy usage, mainly at low level for bombing and reconnaissance missions, was a major factor, while bad weather conditions contributed to almost 50 percent of the accidental losses. The airframes had an average of 6,000 flying hours when phased out, triple that of Germany's F-104s. Surplus CF-104s and CF-104Ds were later transferred to Denmark, Norway, and Turkey.

Republic of China

The Republic of China operated a total of 282 aircraft funded by the Military Assistance Program (MAP); a mixture of new-build and surplus F-104As, -Bs, -Ds, -Gs, -Js, and –DJs; RF-104Gs; and TF-104Gs were used. The Starfighter was phased out of Taiwanese service by 1997.

Denmark

Denmark initially received 25 license-built Canadair F-104Gs and four Lockheed TF-104Gs under the MAP. Surplus Canadian aircraft were transferred between 1972-74 (15 CF-104 and 7 CF-104D). A total of 51 Starfighters were operated by Denmark before their retirement in 1986. Fifteen surplus F-104Gs and three TF-104Gs were transferred to Taiwan in 1987.

A West German Luftwaffe Lockheed F-104F Starfighter aircraft (serial BB+365), in 1960. This aircraft was lost on 19 June 1962 near Knapsack, Nordrhein-Westfalen (Germany), when four planes crashed into the ground after disorientation of the leader. All pilots, three Germans and one American, were killed. Source: U.S. Army.

Germany

Germany received 916 F-104s, comprising 749 F/RF-104Gs, 137 TF-104Gs, and 30 F-104Fs. These aircraft formed the major combat equipment of both the Luftwaffe and Marineflieger. At its peak in the mid-1970s, the Luftwaffe operated five F-104-equipped fighter-bomber wings, two interceptor wings, and two tactical reconnaissance wings. The Marineflieger operated a further two wings of F-104s in the maritime strike and reconnaissance roles.

The Starfighter entered service with the Luftwaffe in July 1960, with deliveries continuing until March 1973, remaining in operational service until October 16, 1987, and continuing in use for test purposes until May 22, 1991. The two squadrons operating the RF-104G were re-equipped with RF-4E Phantoms in the early 1970s.

The Marineflieger initially used AS.30 command guidance missiles as anti-ship weapons, but these were replaced with the more sophisticated and longer-ranged radar-guided AS.34 Kormoran missile, allowing stand-off attacks to be carried out against enemy ships. German Starfighters proved to have an alarming accident rate. In German service, 292 of 916 Starfighters crashed, claiming the lives of 115 pilots.

Greece

Greece received 45 new-built F-104Gs and six TF-104s under the MAP. These were supplemented by secondhand Starfighters passed on from other NATO air forces, including 79 from Germany, 7 from the Netherlands, and 9 from Spain. The Starfighter entered Greek service in April 1964, equipping two wings, and left service in March 1993.

Italy

In the Italian Air Force, the F-104 was a mainstay from the early 1960s until the end of the 20th century. The first flight for an Italian F-104G was a Lockheed-built aircraft, MM6501, on June 9, 1962; however, the first Fiat/Aeritalia-built example flew 2 years later on October 5, 1962. Italy initially received a total of 105 F-104Gs, 24 TF-104Gs, and 20 RF-104Gs, becoming operational in March 1963. This fleet was later increased by the addition of 205 homebuilt F-104Ss and six ex-Luftwaffe TF-104Gs bringing the total number of aircraft operated to 360. In 1986 the Italian Air Force was the largest operator with eleven units flying the Starfighter operationally. Up to 1997, Italy lost 137 (38 percent) of its F-104s in 928,000 flying hours (14.7 aircraft every 100,000 hours). The F-104 was officially retired from Italian Air Force service in 2004.

Japan

The Japan Air Self-Defense Force operated 210 F-104J air-superiority fighters and 20 dual-control trainer F-104DJs. Called *Eiko* (“Glory”), they served from October 1962 to 1986, losing only

36 airplanes in this time. Seven air-superiority squadrons used them: 201, 202, 203, 204, 205, 206, and 207. Japanese F-104s faced intrusive Soviet airplanes during this long service. Many of the Japanese F-104s were eventually converted to drones for aerial target practice.

Jordan

Jordan received 29 F-104As and four F-104Bs under the MAP in 1967. Controlled by the United States, these aircraft were moved temporarily to Turkey during the Arab-Israeli Six-Day War. Replaced by the Northrop F-5 and Dassault Mirage F1 by 1983, the survivors serve as airfield decoys.

Netherlands

The Netherlands operated European-built F-104s. A total of 138 Starfighters were delivered to the Koninklijke Luchtmacht (Royal Netherlands Air Force). Many Dutch aircraft were transferred to Turkey.

Norway

Norway received 18 surplus CF-104s and four CF-104Ds from Canada in 1974; the country had initially received 19 Canadair-built F-104Gs and four TF-104Gs in 1963 under the MAP. The F-104 was phased out of Norwegian service in late 1982.

Pakistan

Pakistan was the first non-NATO country to be equipped with the F-104. A total of 12 F-104As and 2 F-104B were delivered; 9 F-104As (tail numbers 56-803, 56-804, 56-805, 56-807, 56-868, 56-874, 56-875, 56-877, and 56-879) and 2 F-104Bs (tail numbers 57-1309, 57-1312) on August 5, 1961, although some sources say the first two were landed at Sargodha Airbase by Sqn. Ldr. Sadruddin and Flt. Lt. Middlecoat in 1962. One more F-104A (tail number 56-773) was delivered on June 8, 1964, and another (tail number 56-798) on March 1, 1965. These were ex-USAF aircraft retrofitted with the more powerful J-79-11A engine and, at the PAF's request, the 20 mm Vulcan gun was reinstalled after removal by the USAF. These F-104s had unusually high thrust-to-weight ratios due to the older but lighter airframe and more modern engines. The F-104 was in service for 12 years with 11,690 flight hours (246 hours 45 minutes of these in the 1965 Indo-Pakistan War and 103 hours 45 minutes in the 1971 Indo-Pakistan War), after which five F-104s remained and were grounded by lack of spares due to a U.S. embargo on military equipment. The type was phased out in late 1972.

Spain

The Spanish Air Force received its F-104s under the MAP: 18 Canadair-built F-104Gs and 3 Lockheed-built TF-104Gs were delivered under the MAP to Spain's Ejército del Aire in 1965. These aircraft were transferred to Greece and Turkey when they were replaced by F-4 Phantoms in 1972. It is notable that no aircraft were lost through accidents during 17,000 hours of operational use in Spain, although it should also be noted that the aircraft was used only in its intended role of an interceptor and mainly in very good flying weather.

Turkey

Turkey received 48 new-build F-104Gs and 6 TF-104Gs from Lockheed and Canadair production, funded under the MAP, which were delivered from 1963, and directly purchased 40 new F-104S interceptors from Fiat in 1974 and 1975. In addition, like Greece, Turkey received many surplus Starfighters from several NATO nations in the 1970s and 1980s, including 170 ex-German aircraft, 53 aircraft from the Netherlands, and 52 from Canada. In total, Turkey received over 400 Starfighters from various sources, although many of these aircraft were broken up for spares without having been flown. The F-104 was finally retired from Turkish service in 1995.

F-104 Civil Operators

NASA

Eleven F-104s (different versions) were operated by NASA between 1956 and 1994. The aircraft were used in support of X-15 and XB-70 flight testing and for astronaut training during various spaceflight programs. NASA F-104 aircraft were used to gather flight research data, including aircraft handling characteristics such as roll inertia coupling and reaction control systems as used in the NF-104A and X-15. Space Shuttle thermal protection tiles were tested in flights aboard a Starfighter on a rig that simulated flight through rain. NASA’s Starfighters flew many safety chase sorties in support of advanced research aircraft over the years, including the wingless lifting body aircraft. Neil Armstrong was one notable pilot who flew a NASA F-104.

The Starfighters F-104 Demo Team

The team based in Clearwater, Florida currently operates three Canadair CF-104 Starfighters, performing at air shows across the United States and Canada. The team’s CF-104s consist of a two-seat CF-104D Serial No. 104632 (registered as N104RB), and two single-seat CF-104s Serial

Nos 104850 (registered as N104RD) and 104759 (registered as N104RN). The aircraft were originally operated with the Royal Canadian Air Force and all later served with the Royal Norwegian Air Force before being imported into the United States in the early 1990s.

F-104RB "Red Baron"

Another civilian Starfighter, called the F-104RB (for Manfred von Richthofen, the "Red Baron"), was used to set the low-level speed record in October 1977 by world-famous air racer Daryl Greenamyer. Greenamyer built his F-104 over a period of 12 years from parts scrounged from various places, including a "borrowed" J79-17/1 turbojet from a McDonnell Douglas F-4 Phantom, which developed over 2,000 lb more thrust than the standard J79-19 engine. Greenamyer set the record at Mud Lake, near Tonapah, Nevada, recording a top speed of 988.26 mph (1,590.41 km/h) after five passes over the dry lake. He remained supersonic for most of the 20-minute flight, and rarely rose much higher than 100 ft above the lake bed. Several months later, while practicing for an attempt on the world absolute altitude record, he was forced to eject when his landing gear failed to extend; a belly landing in the F-104 was considered too dangerous to attempt.

Crewmen from the Japanese Air Self-Defense Force performing maintenance on a JASDF F-104 Starfighter aircraft, during Exercise Cope North '81-3. Source: defernseimagery.mil.

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Issue #	Issue(s)	Recommended Review, Action(s), and Coordination with Applicant	Notes, Action(s) Taken, and Disposition
F-104 Preliminary and General Airworthiness Inspection Issues			
1.	Aviation Safety (AVS) Safety Management System (SMS) Guidance	Use the AVS SMS guidance as part of the airworthiness certification process, as it supplements the existing Code of Federal Regulations (CFR). FAA Order VS8000.367 (May 14, 2008) and FAA Order VS8000.369 (September 30, 2008) are the basis for, but not limited to (1) identifying hazards and making or modifying safety risk controls, which are promulgated in the form of regulations, standards, orders, directives, and policies, and (2) issuing certificates. AVS SMS is used to assess, verify, and control risks, and safety risk management is integrated into applicable processes. Appropriate risk controls or other risk management responses are developed and employed operationally. Safety risk management provides for initial and continuing identification of hazards and the analysis and assessment of risk. The FAA provides risk controls through activities such as the promulgation of regulations, standards, orders, directives, advisory circulars (AC), and policies. The safety risk management process (1) describes the system of interest, (2) identifies the hazards, (3) analyzes the risk, (4) assesses the risk, and (5) controls the risk.	
2.	Temporary Extensions	Field offices should not consider temporary extensions of existing F-104 airworthiness certificates.	
3.	Aircraft Familiarization	Become familiar with the F-104 before initiating the certification process. One of the first steps in any aircraft certification is to be familiar with the aircraft in question. Such knowledge, including technical details, is essential in establishing a baseline as the certification process moves forward.	
4.	Preliminary Assessment	Conduct a preliminary assessment of the aircraft to determine condition and general airworthiness. A Manufacturing Inspection District Office (MIDO) inspector may seek Flight Standards District Offices (FSDO) support as part of this process. Coordination between the offices may be essential in ensuring adequate technical expertise.	
5.	Condition for Safe Operation	This is an initial determination by an FAA inspector or authorized representative of the Administrator that the overall condition of an aircraft is conducive to safe operations. This refers to the condition of the aircraft relative to wear and deterioration. The FAA inspector will make an initial determination as to the overall condition of the aircraft. The aircraft items evaluated depend on information such as aircraft make, model, age, type, completeness of maintenance records of the aircraft, and the overall condition of the aircraft.	
6.	Main Safety Issues	The main goal of this document is to assist the FAA in eliminating preventable accidents and those accidents and incidents caused by well-known problems that were either not fixed operationally or require specific mitigation to be contained. In other words, unnecessary risks must be mitigated. This document addresses the following general safety concerns regarding former military high-performance aircraft. • Lack of consideration of inherent and known design failures; • Several single-point failures; • Lack of consideration for operational experience, including accident data and trends; • Operations outside the scope of the airworthiness certificate being sought; • Insufficient flight test requirements; • Unsafe and untested modifications; • Operations over populated areas (the safety of the non-participating public has not been properly addressed in many cases); • Operations from unsuitable airports; • High-risk passenger carrying activities taking place; • Ejection seat safety and operation not adequately addressed; • Weak maintenance practices to address low reliability of aircraft systems and engines; • Ignoring required inspection schedules and procedures; • Limited pilot qualifications, proficiency, and currency; • Weapon-capable aircraft not being demilitarized, resulting in unsafe conditions; • Extensive brokering; • Extensive use of unqualified Designated Airworthiness Representatives (DAR); • Accidents and serious incidents not being reported; and • Inadequate accident investigation data.	

Issue #	Issue(s)	Recommended Review, Action(s), and Coordination with Applicant	Notes, Action(s) Taken, and Disposition
7.	Denial	The FAA will provide a letter to the applicant stating the reason(s) for denial and, if feasible, identify which steps may be accomplished to meet the certification requirements if the aircraft does not meet them and the special airworthiness certificate is denied. Should this occur, a copy of the denial letter will be attached to FAA Form 8130-6, Application for U.S. Airworthiness Certificate, and forwarded to AFS-750, and made a part of the aircraft's record.	
8.	Potential Reversion Back to Phase I	Notify the applicant that certain modifications to the aircraft will invalidate Phase II. These include: (a) structural modifications, (b) aerodynamic modifications, including externally mounted equipment except as permitted in the limitations issued, and (c) change of engine make, model, or power rating (thrust or horsepower). The owner/operator may return the aircraft to Phase I to flight test specific items as required. However, major modifications such as those listed above may require new operating limitations. Phase I may have to be expanded as well. In August 2012, the National Transportation Safety Board (NTSB) issued safety recommendations concerning a fatal accident of an experimental high-performance aircraft that had undergone extensive modifications. The NTSB noted "the accident airplane had undergone many structural and flight control modifications that were undocumented and for which no flight testing or analysis had been performed to assess their effects on the airplane's structural strength, performance, or flight characteristics. The investigation determined some of these modifications had undesirable effects. For example, using a single, controllable elevator trim tab (installed on the left elevator) increased the aerodynamic load on the left trim tab (compared to a stock airplane, which has a controllable tab on each elevator). Also, filler material on the elevator trim tabs (both the controllable left tab and the fixed right tab) increased the potential for flutter because it increased the weight of the tabs and moved their center of gravity aft, and modifications to the elevator counterweights and inertia weight made the airplane more sensitive in pitch control. It is likely, had engineering evaluations and diligent flight testing for the modifications been performed, many of the airplane's undesirable structural and control characteristics could have been identified and corrected." As part of the probable cause, the NTSB stated "contributing to the accident were the undocumented and untested major modifications to the airplane and the pilot's operation of the airplane in the unique air racing environment without adequate flight testing." As a result of this investigation, the NTSB issued safety recommendations, including requiring "aircraft owners to provide an engineering evaluation that includes flight demonstrations and analysis within the anticipated flight envelope for aircraft with any major modification, such as to the structure or flight controls."	
9.	Identify F-104 Version and Sub-Variants	Identify the version and variant of the F-104. There will likely be differences among and between the different F-104 aircraft. These differences and their impact on the airworthiness of the aircraft are discussed throughout this document. In addition to the different versions of the aircraft, i.e., the F-104A, B, C, D, F. G, J, and S models, as well as TF-104 models there are significant differences between aircraft in the version. Remember these aircraft were manufactured under license in at least 5 countries by different companies other than Lockheed. These differences included: afterburner nozzle type, LOX oxygen system, refueling probe, modification to and different ejection seat systems, and changes in the antenna configuration and fuel systems.	
10.	Major Structural Components	Ask the applicant to identify and document the origin, condition, and traceability of major structural components.	
11.	Aircraft Records	Request and review the applicable military and civil aircraft records, including aircraft and J79 engine logbooks. Depending on country and company manufacturer, these could be in English, German, Danish, Italian, or Japanese. The F-104 was produced by companies such as Canadair, a Fiat led consortium of Aerfer, Macchi, Piaggio, SACA and SIAI-Marchetti, and a German consortium of Fokker and Aviolanda, Focke-Wulf, Hamburger Flugzeugbau or a different group with Messerschmitt, Dornier, Heinkel and Siebel. Starfighters were also built by Mitsubishi under license.	
12.	PTRS Entries for Malfunctions and Defects Reports	If the applicant reports malfunctions and defects, make a PTRS entry accordingly. See *Reporting Malfunctions and Defects* below.	
13.	Data Plate, Block Number and Serial Number	Verify the military identification plate is installed. Record all information contained on the identification plate. Block number and serial number also need to be identified.	
14.	Technical Order (TO) 00-5-1, AF Technical Order System	Become familiar with TO 00-5-1, AF Technical Order System, dated May 1, 2011, if applicable. This document provides guidance in the U.S. Air Force (USAF) TO system, which may guide much of the documentation associated with the F-104.	
15.	Aircraft Ownership	Establish and understand the aircraft's ownership status, which sets the stage for many of the responsibilities associated with operating the F-104 safely. There are many cases where former military aircraft are leased from other entities, and this can cloud the process. For example, if the aircraft is leased, the terms of the lease may be relevant as part of the certification because the lease terms may restrict what can be done to the aircraft and its operation for safety reasons.	
16.	FAA Records Review	Review the existing FAA airworthiness and registration files (EDRS) and search the Program Tracking and Reporting Subsystem (PTRS) for safety issue(s) and incidents.	

Issue #	Issue(s)	Recommended Review, Action(s), and Coordination with Applicant	Notes, Action(s) Taken, and Disposition
17.	FAA Form 8100-1	Use FAA Form 8100-1, Conformity Inspection Record, to document the airworthiness inspection. Using this form facilitates the listing of relevant items to be considered, those items' nomenclature, any reference (that is, NATO manual; FAA Order 8130.2, Airworthiness Certification of Aircraft and Related Products; regulations) revision, satisfactory or unsatisfactory notes, and comments. Items to be listed include but are not limited to— 1. FAA Form 8130-6; 2. 14 CFR § 21.193; 3. FAA Form 8050-1, Aircraft Registration Application; 4. 14 CFR § 45.11(a); 5. FAA Order 8130.2, paragraphs 4002a(7) and (10), 4002b(5), 4002b(6), 4002b(8), 4111c, and 4112a(2); 6. 14 CFR § 91.205; 7. § 91.417(a)(2)(i), airframe records and total time, overhaul; and 8. § 91.411/91.413, altimeter, transponder, altitude reporting, static system test.	
18.	Airframe and J79 Engine Data	Ask applicants to provide the following: Airframe: • Import country (if applicable), • N-Number, • Manufacture year and serial number, and • Airframe time and airframe cycles. J79 engine: • Type and variant, • Manufacture date and serial number, and • Overhaul data, location, provider, and J79 engine time and cycles. Properly identifying the relevant and basic characteristics of the airframe and the engine is necessary to address the safety issues with the F-104. The following excerpt from an NTSB report on a former military jet accident illustrates the seriousness of adequate records: "On May 15, 2005, a British Aircraft Corporation 167 Strike Master MK 83, N399WH, registered to DTK Aviation, Inc., collided with a fence during an aborted takeoff from Boca Raton Airport, Boca Raton, Florida. The airplane was substantially damaged and the commercial-rated pilot and passenger sustained minor injuries. The pilot initially stated he performed a preflight inspection of the aircraft which included a flight control continuity check. He had the passenger disable the gust lock for the flight controls. He performed a flight control continuity check before taxiing onto the runway for takeoff; no discrepancies were reported. The takeoff roll commenced and at the calculated rotation speed (70 knots), he '...began to apply pressure to stick and noticed an unusual amount of load on the controls. I made a quick trim adjustment to ensure that the forces on the stick were not the results of aerodynamic loads. When the trim changes yielded no change, I initiated an abort (at approximately Vr at 80 knots) by retarding the throttle, extending the speed brakes, and applying the wheel brakes.' He notified the tower of the situation, briefed the passenger, and raised the flaps. He also opened the canopy after realizing that he was unable to stop on the runway. The airplane traveled off the end of the runway, rolled through a fence and came to rest upright. The pilot also stated that the airplane is kept outside on the ramp at the Boca Raton Airport. Examination of the airplane by an FAA operations inspector before recovery revealed the control column would only move aft between 1/4 and 1/2 inch. No determination was made as to the position of the control lock in the cockpit. Examination of the airplane following recovery by an FAA airworthiness inspector revealed that the elevator was free to travel through the full range but was noted to be '...very stiff.' Additionally, the rudder was '...extremely hard to move in either direction." During movement of the elevator flight control surface, the rudder flight control surface was noted to move, and with movement of the rudder flight control surface, the elevator flight control surface was noted to move. A review of a United Kingdom Civil Aviation Authority (U.K. CAA) Mandatory Permit Directive (MPD) No. 2002-001 R1, issued on January 16, 2003, indicates "partial binding or complete seizure of the elevator/rudder concentric torque tube bearings causing an interconnect between elevator and rudder control systems. This interconnection has resulted in un-commanded rudder movement with the application of elevator control inputs and vice versa. Investigation has determined that bearing seizure was due to inadequate lubrication and water ingress in the elevator torque tube bearings. Aircraft subject to external storage are particularly prone to this occurrence. A review of the airplane maintenance records revealed the airplane was last inspection on June 29,2004, in accordance with, '...the scope and detail of the inspection program approved by the FSDO for BAC Strikemaster dated June 29, 2001, and found it to be in safe operating condition at this time.' The logbook entry does not indicate airplane total time; therefore, the time since the inspection was not determined. There was no record that U.K. CAA MPD No. 2002-001 R1 had been complied with."	
19.	Functionality Check	Ask the applicant to prepare the F-104 for flight, including all preflight tasks, startup, run-up, and taxi.	
20.	Accident and Incident Data System	Review the NTSB accident database and the FAA's Accident and Incident Data System for the F-104 type accidents and incidents. Refer to http://ntsb.gov and http://www.asias.faa.gov.	

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21.	Accident and Incident History	Ask the applicant to provide any data concerning all accidents and/or incidents involving the F-104.	
22.	Adequate F-104 Manuals and Related Documentation (USAF Technical Orders)	Ensure the existence of a complete set of the applicable USAF TOs, such as flight manuals, inspections and maintenance manuals. Typically, this may involve over 100 such documents. The operator must have the applicable TOs to address known issues related to airworthiness, maintenance, and servicing. Some of the relevant F-104 manuals include — • *TO 1F-104-1, Flight Manual USAF Series;* • *TO 1F-104-1-1, Performance Supplement;* • *TO 1F-104-2, General Airplane Organizational Maintenance Technical Manual;* • *TO 1F-104-3, Aircraft Structural Repair Instructions Manual;* • *TO 1F-104-23, Corrosion Control;* • *TO 1F-104-36, Nondestructive Inspection;* • *TO 1F-104-2-2, Ground Handling, Servicing and Airframe Maintenance Technical Manual;* • *TO 1F-104-2-3, Hydraulically Operated Systems and Utility Systems Technical;* • *TO 1F-104-2-4, Flight Control Systems;* • *TO 1F-104-2-5, Power Plant;* • *TO 1F-104-4-6, Power Plant;* • *TO 1F-104-2-7, Electrical Systems;* • *TO 1F-104-4-7, Electrical Systems;* • *TO 1F-104-4-8, Landing Gear Systems;* • *TO 1F-104-2-3, Flight Controls Systems;* • *TO 1F-104-4-9, Instruments;* • *TO 1F-104-4, Aircraft Illustrated Parts Breakdown Manual;* • *TO 1F-104-2-8, Aircraft Organizational Maintenance Manual - Wiring Diagrams and Data;* • *TO 1F-104-5, Basic Weigh Checklist and Loading;* • *TO 11P1-31-7, Specialized Storage and Maintenance Procedures - Rocket Catapult & Ballistic Catapult;* • *TO 11P6-1-7, Specialized Storage and Maintenance Procedures - Cartridge Actuated Thrusters; and* • *TO 11P3-1-7, Specialized Storage and Maintenance Procedures - Cartridges Actuated Initiators.* For additional TOs, refer to http://www.newportaero.com/air_force_technical_order_search.php?s=100&q=1T-38A&stype=TO number.	
23.	Operational Supplements	Ensure the owner/operator has a complete set of the applicable military manuals (that is, USAF or NATO) and operational supplements to safely operate an F-104.	
24.	Availability of Documents Listed in the Applicable Aircraft List of Applicable Publication Manual	Review the F-104 aircraft inspection program (AIP) to verify compliance with the applicable version of the F-104 list of applicable publication manuals or equivalent document.	
25.	Applicant/Operator Capabilities	Review the applicant/operator’s capabilities, general condition of working/storage areas, availability of spare parts, and equipment.	

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26.	"Destroyed" Aircraft	Determine whether the aircraft was rebuilt from a "destroyed" aircraft. This is important because in some cases, aircraft have been rebuilt "around the data plate," and determining whether or not it meets its original design can be difficult. The NTSB defines "destroyed" as damaged due to impact, fire, or in-flight failures to an extent not economically repairable. FAA Order 8020.11A, Aircraft Accident and Incident Notification, Investigation, and Reporting, dated August 2, 1991, defines destroyed aircraft as "aircraft damaged to the extent that it would be impracticable to return the aircraft to an airworthy condition." FAA Order 8130.2 notes that FAA aviation safety inspectors (ASI) should be on alert for any indication of ID plate misuse or suspicious activity, such as the building of a complete aircraft by a person performing work under 14 CFR part 43. Installation of an ID plate by a person performing work under 14 CFR part 43, where the ID plate has been purchased or salvaged from another aircraft, is not approved unless written approval is obtained from the FAA. Before issuing an airworthiness certificate for an aircraft that appears to be a repair or restoration of an aircraft that previously has been destroyed or demolished, the ASI should seek the assistance of the manager of AFS-750. That office can assist the ASI in determining whether the serial number of the aircraft on which certification is sought is the serial number of an aircraft previously classified as destroyed or demolished by the FAA or the NTSB. If the ASI determines the ID plate comes from a previously destroyed or demolished aircraft, the ASI must initiate an investigation to determine whether a violation of 14 CFR § 45.13(c) or (e) has occurred before the airworthiness certificate may be issued. If a violation of 14 CFR § 45.13(c) or (e) is found, the ASI must deny the airworthiness certificate and initiate an enforcement action.	
27.	Scope and Qualifications for Restoration, Repairs, and Maintenance	Familiarize yourself with the scope of the restoration, repairs, and maintenance conducted by or for the applicant.	
28.	Limiting Duration of Certificate	Refer to § 21.181 and FAA Order 8130.2, regarding the duration of certificates, which may be limited. An example would be to permit operations for a period of time to allow the implementation of a corrective action or changes in limitations. In addition, an ASI may limit the duration if there is evidence additional operational requirements may be needed at a later date.	
29.	Compliance With § 91.319(a)(1)	Inform the operator that the use of the F-104 is limited under this regulation. The F-104 cannot be operated for any purpose other than the purpose for which the certificate was issued. For example, in the case of an experimental exhibition certificate, the certificate can be used for air show demonstrations, proficiency flights, and flights to and from locations where the maintenance can be performed. Such a certificate is NOT IN EFFECT for flights related to providing military services (that is, air-to-air gunnery, target towing, electronic countermeasures (ECM) simulation, cruise missile simulation, and air refueling). Also refer to *Military/Public Aircraft Operations* below.	
30.	Multiple Certificates	Ensure the applicant submits information describing how the F-104 configuration is changed from one to the other in those cases involving multiple airworthiness certificates. This is important because, for example, some research and development (R&D) activities may involve equipment that must be removed to revert back to the exhibition configuration (refer to *R&D Airworthiness Certification* below). Moreover, the procedures should provide for any additional requirement(s), such as additional inspections, to address situations such as high-G maneuvering that could impact the aircraft and/or its operating limitations. Similarly, it should address removing R&D equipment that could be considered part of a weapon system (refer to *Demilitarization* below). All applications for an R&D certificate must adhere to FAA Order 8130.29, Issuance of a Special Airworthiness Certificate for Show Compliance and/or Research and Development Flight Testing.	
31.	Public Aircraft Operations (PAO), State Aircraft Operations, Military Support Missions, Department of Defense (DOD) contracts	The special airworthiness certificate and attached operating limitations for this aircraft are not in effect during PAO as defined by Title 49 of the United States Code (49 U.S.C.) §§ 40102 and 40125. They are also not in effect during state aircraft operations (typically military support missions or military contracts), as defined by Article 3 of the International Civil Aviation Organization's (ICAO) Convention on International Civil Aviation. *Aircraft used in military services are deemed state aircraft.* Also refer to *Restrictions on Operations Overseas* below.	
32.	Re-Conforming to Civil Certificate	Ensure the F-104 is returned, via an approved method, to the condition and configuration at the time of airworthiness certification before operating under the special airworthiness certificate issued following a public, state, or military aircraft operation. This action must be documented in a log or daily flight sheet. Ensure the applicant submits information describing how the aircraft configuration is changed from PAO, state aircraft, or other non-civil classification or activity back to a civil certificate. This is important because, for example, some military support activities may involve equipment or maneuvers that must be removed or mitigated to revert back to original exhibition or R&D configuration. Moreover, the procedures should provide for any additional requirement(s), such as additional inspections, to address situations such as high-G maneuvering and sustained Gs that could have an impact on the aircraft and/or its operating limitations. Similarly, it should address removing equipment that could be considered part of a weapon system. Refer to *Demilitarization* below.	

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33.	R&D Airworthiness Certification	R&D certification requires a specific project. Ensure the applicant provides detailed information such as— • Description of each R&D project providing enough detail to demonstrate it meets the regulatory requirements of § 21.191(a); • Length of each project; • Intended aircraft utilization, including the number of flights and/or flight hours for each project; • Aircraft configuration; • Area of operation for each project; • Coordination with foreign CAA, if applicable; and • Contact information for the person/customer that may be contacted to verify this activity. Note: All applications for an R&D certificate should include review of FAA Order 8130.29.	
34.	Demilitarization	Verify the F-104 has been adequately demilitarized. This F-104 must remain demilitarized for all civil operations. Refer to the applicable technical guidance. A weapon, a weapon system, and related equipment can create safety of flight hazards under the jurisdiction of the FAA and must be removed. Removal of the M61 Vulcan Gatling cannon alone does not suffice. Other systems include: gun sight, pylons and wiring (in the case of wiring, the firing circuitry must not have any continuity to it), radar (made inoperable), chaff, flares or practice bombs, ECM/jamming gear, firing control (armament) panel(s), switches and triggers, and combing computers and systems. With these systems, many safety issues that can preclude a finding of "condition for safe operation," and "protecting people and property on the ground," as required by statute and regulations. These safety issues include accidental firing, compartment fires, inadvertent discharge of flares, toxic chaff, electrical overloads of the aircraft electric system, danger of inadvertent release, structural damage to the aircraft, complex flight limitations, and harmful emissions. Note: Some of these weapon systems could be permitted for an R&D airworthiness certificate, but the related safety issues still have to be addressed, especially if the aircraft reverts back to an exhibition certificate. TO 00-80G-1, Make Safe Procedures for Public Static Display, dated November 30, 2002, can be used as a reference as well.	
35.	Safety Discretion	The field inspector may add any requirements necessary for safety. Under existing regulations and policies, FAA field inspectors have discretion to address any safety issue that may be encountered, whether or not it is included in the job aid. Of course, in all cases, there should be justification for adding requirements. In this respect, the job aid provides a certain level of standardization to achieve this, and in addition, AIR-200 is available to coordinate a review (with AFS-800 and AFS-300) of any proposed limitations an inspector may consider adding or changing. 49 U.S.C. § 44704 states before issuing an airworthiness certificate, the FAA will find the aircraft is in condition for safe operation. In issuing the airworthiness certificate, the FAA may include terms required in the interest of safety. This is supported by case law. 14 CFR § 21.193, Experimental Certificates: General, requires information from an applicant, including, "upon inspection of the aircraft, any pertinent information found necessary by the Administrator to safeguard the general public." 14 CFR § 91.319, Aircraft Having Experimental Certificates: Operating, provides "the Administrator may prescribe additional limitations that the Administrator considers necessary, including limitations on the persons that may be carried in the aircraft." Finally, FAA Order 8130.2, chapter 4, Special Airworthiness Certification, effective April 16, 2011, also states the FAA may impose any additional limitations deemed necessary in the interest of safety.	
36.	2009 Crash of ZU-BEX	Recommend the accident report concerning the 2009 Lightning T5 ZU-BEX be reviewed in detail. This report, published by the South African CAA in August 2012, provides valuable insight into the consequences of operating complex and high-performance former military aircraft in an unsafe manner. The relevant issues identified in the report include (1) ignoring operational history and accident data, (2) inadequate maintenance practices, (3) granting extensions on inspections, (4) poor operational procedures, and (5) inadequate safety oversight. Many of the issues discussed and documented in the accident investigation report are directly relevant to safety topics discussed in this document. The South African CAA report can be found at http://www.caa.co.za/.	
37.	Importation	Review any related documents from U.S. Customs and Border Protection and the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) for the F-104. If the aircraft was not imported as an aircraft, or if the aircraft configuration is not as stated in Form ATF-6, it may not be eligible for an airworthiness certificate. There are many cases in which Federal authorities have questioned the origin of a former military aircraft and its installed weapon system. Some have been seized. For example, two T-28s were seized at the Canadian border by U.S. Customs officials in 1989. A MiG-23 was seized in 1992 because it entered the United States with part of its armament. Refer to Federal Firearms Regulations Reference Guide, ATF Publication 5300.4, Revised September 2005, for additional guidance.	
38.	Brokering	Verify the application for airworthiness does not constitute brokering. Section 21.191(d) was not intended to allow for the brokering or marketing of experimental aircraft. This includes individuals who manufacture, import, or assemble aircraft, and then apply for and receive experimental exhibition airworthiness certificates so they can sell the aircraft to buyers. Section 21.191(d) only provides for the exhibition of an aircraft's flight capabilities, performance, or unusual characteristics at air shows, and for motion picture, television, and similar productions. Certificating offices must verify all applications for exhibition airworthiness certificates are for the purposes specified under § 21.191(d) and are from the registered owners who will exhibit the aircraft for those purposes. Applicants must also provide the applicable information specified in § 21.193.	

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39.	Restrictions on Operations Overseas	Inform the applicant/operator that operations may be restricted and permission must be granted by a foreign CAA. The applicable CAA may impose any additional limitations it deems necessary, and may expand upon the restrictions imposed by the FAA on the aircraft. In line with existing protocols, the FAA will provide the foreign CAA any information, including safety information, for consideration in evaluating whether to permit the operation of the aircraft in their country, and if so, under what conditions and/or restrictions. It is also noted any operator offering to use a U.S. civil aircraft with an experimental certificate to conduct operations such as air-to-air combat simulations, ECM, target towing for aerial gunnery, and/or dropping simulated ordinances pursuant to a contract or other agreement with a foreign government or other foreign entity would not be doing so in accordance with any authority granted by the FAA as the State of Registry or State of the Operator. On the issue of operations overseas: ➢ Under international law, the aircraft will either be operated as a civil aircraft or a state aircraft. The aircraft cannot have a combined status. If the aircraft are to be operated with civil status, then they must have FAA-issued airworthiness certificates. If the applicant/operator is seeking experimental certificates for R&D or Exhibition purposes for the aircraft, and if the FAA issues (or renews) those certificates for the aircraft, then the only permissible operation of the aircraft as civil aircraft in a foreign country, is for an R&D or Exhibition purpose. The applicant/operator cannot be allowed to accomplish other purposes during the same operation, such as performing the contract for a foreign air force. This position is necessary to avoid telling an operator that any R&D or Exhibition activity could serve as a cover for a whole host of improper activities using an aircraft with an experimental certificate for R&D or Exhibition purposes, rendering the R&D or Exhibition limitation on the certificate meaningless. ➢ The R&D or Exhibition activity would be a pretext for the real purpose of the operation. Accordingly, in issuing experimental certificates for an R&D or Exhibition purpose, the FAA must make it clear that any other activities or purposes for the operation are outside the scope of permitted operations under the certificate. The FAA must also make clear that the operation as a civil aircraft requires the permission of the foreign civil aviation authority (CAA). In requesting that permission, the applicant/operator should advise the foreign aviation authority that the operation will be for an R&D or Exhibition purpose only and for no other purpose, including performing a contract for any foreign military organization. ➢ The applicant/operator must understand that if the foreign CAA asks FAA about the operation, the FAA will state “that the only permissible purpose of the operation is R&D or Exhibition, and an operation for any other purpose, even when conducted in conjunction with an R&D or Exhibition purpose, is outside the scope of the operations allowed under the certificate. ➢ If the applicant/operator operates the aircraft as state aircraft, then the national government of some country will have designated the aircraft as its state aircraft, and the host country, will have given the aircraft permission to operate through the issuance of a diplomatic clearance. That diplomatic clearance should include whatever terms and conditions that CAA deems necessary or appropriate for the operation. ➢ The aircraft, when operated as state aircraft, does not need an FAA airworthiness certificate, and the pilots of those aircraft do not need to hold FAA-issued airman licenses. Safety oversight responsibility for aircraft designated as state aircraft rests with the country that made the state aircraft designation. ➢ If a country issues a diplomatic clearance for the operation of the aircraft, the aircraft would be deemed to be a state aircraft of the country requesting that clearance. Safety oversight would rest with the military service that requested the diplomatic clearance.	
40.	Federally Obligated Airport Access	Inform the operator that operations may be restricted by airports because of safety considerations. As provided by 49 U.S.C. § 47107(a), a federally obligated airport may prohibit or limit any given type, kind, or class of aeronautical use of the airport if such action is necessary for the safe operation of the airport or necessary to serve the civil aviation needs of the public. Additionally, per FAA Order 5190.6, FAA Airport Compliance Manual, the airport should adopt and enforce adequate rules, regulations, or ordinances as necessary to ensure safety and efficiency of flight operations and to protect the public using the airport. In fact, the prime requirement for local regulations is to control the use of the airport in a manner that will eliminate hazards to aircraft and to people on the ground. In all cases concerning airport access or denial of access, and based on FAA Flight Standards Service safety determination, FAA Airports is the final arbiter regarding aviation safety and will make the determination (Director’s Determination, Final Agency Decision) regarding the reasonableness of the actions that restrict, limit, or deny access to the airport (refer to FAA Docket 16-02/08, FAA v. City of Santa Monica, Final Agency Decision; FAA Order 2009-1, July 8, 2009; and FAA Docket 16-06-09, Platinum Aviation and Platinum Jet Center BMI v. Bloomington-Normal Airport Authority).	
41.	Environmental Impact (Noise)	Inform the operator that operations may be restricted by airport noise access restrictions and noise abatement procedures in accordance with 49 U.S.C. § 47107. As a reference, refer to FAA Order 5190.6.	

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42.	Initial Contact Checklist	The following is a sample of the contents of an initial contact by an FAA field office to an applicant concerning a proposed certification. It addresses many of the major safety and risk issues with the aircraft and will assist in (1) preparing an airworthiness applicant, (2) making corrections and updating any previous application, and (3) documenting the level of airworthiness review. 1. Discuss item missing from the application. a. Program letter setting the purpose for which the aircraft will be used. i. Exhibition of aircraft flight capabilities, performance, unusual characteristics at air shows, motion picture, television and similar productions, and maintenance of exhibition flight proficiency, including flying to and from such air shows and productions. ii. Aircraft cannot be certified if the intention is to broker or sell the aircraft. iii. Aircraft photos. 2. Prepare aircraft and documentation for FAA inspection. a. Maintenance and modification records. b. Aircraft history and logbooks (airframe, engine, and components). c. Have the aircraft maintenance program ready for review and acceptance. d. Have operations and maintenance and supplements. e. Have crew qualifications ready for review (pilot, mechanics, airframe and powerplant (A&P), IA or Inspection Authorization). f. Be prepared to show spare parts records. g. Be prepared to accomplish preflight, ground checks, run-up, and taxi checks. h. Be prepared to demonstrate the aircraft has been demilitarized. i. Have records on status of ejection seats. j. Be prepared to discuss required ground support equipment and specialized tooling for maintenance. k. Be prepared to discuss and document the airframe fatigue life program compliance. l. Be prepared to discuss engine thrust measurement process. m. Be prepared to demonstrate oxygen system checks. n. If “G” suits are used be prepared to demonstrate serviceability. o. Have records for any fabricated parts and engineering documentation if required. p. Have records on flight control balancing. q. Have weight and balance records. r. Be prepared to discuss external stores. s. Be prepared to discuss Phase I test flights (recommended 10 hours). t. Have record of installed avionics. 3. Applicable regulations and ACs. a. §§ 21.93, 21.181, 21.193, 21.191(d), 23.1441, 43.3, 43.9, 45.11, 45.23(b), 45.25, 45.29, 91.205, 91.307, 91.319(a)(1), 91.407, 91.409(f)(4), 91.411, 91.413, 91.417, 91.1037, 91.1109, and AC 43-9, AC 91-79. 4. Items to discuss with applicant. a. Recommendation of establishing a minimum equipment list. b. Recommend establishing minimum pilot experience and proficiency, including (1) FAA PIC policy, USAF/NATO training, (2) 10 to 15 hours of dual time, and (3) 3 hours per month, and five takeoffs and landings. c. Recommend establishing minimum runways length criteria for takeoff and landing. d. Discuss military use, that is, declaration of public use operations (PAO) and operating limitations.	

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F-104 Maintenance Manual(s), Aircraft Inspection Program (AIP), and Servicing			
43.	Changes to AIP	Consider whether the FAA-accepted AIP is subject to revisions to address safety concerns, alterations, or modifications to the F-104. Section 91.415, Changes to Aircraft Inspection Programs, requires “whenever the Administrator finds that revisions to an approved aircraft inspection program under § 91.409(f)(4) or § 91.1109 are necessary for the continued adequacy of the program, the owner or operator must, after notification by the Administrator, make any changes in the program found to be necessary by the Administrator.” As provided by § 91.415, review the submitted maintenance manual(s) and AIP. Work with the applicant to revise the AIP as needed based on any concerns identified in this table (Attachment 2). For example, an AIP can be modified to address or verify— • Consistency with the applicable military TOs for airframe, powerplant, and systems to verify replacement/interval times are addressed. • All AIP section and subsections include the proper guidance/standards (that is, USAF TOs) for all systems, groups, and tasks. • No “on condition” inspections for items that have replacement times unless proper technical data to substantiate the change, that is, aileron boost and oxygen regulator. • Ejection seat system replacement times are adhered to. No “on condition” inspections for rocket moors and propellants. Make the distinction between replacement times, that is, “shelf life” vs. “installed life limit.” • Any deferred log is related to a listing of minimum equipment for flight (refer to *Minimum Equipment for Flight* below, and Air Force Instructions (AFI) 21-103); and • Inclusion of document revision page(s).	
44.	AIP Is Not a Checklist	Ensure the AIP stresses it is not a checklist. This is important in many cases because the actual AIP is only a simple checklist and actual tasks/logbook entries say little of what was actually accomplished and to what standard. This is one of the major issues with some FAA-approved inspection programs, and stems from confusion about the different nature of (1) aircraft maintenance manuals, (2) AIPs, and (3) inspection checklists. Unless a task or item points to technical data (not just a reference to a manual), it is simply a checklist, not a manual. Ensure the AIP directs the reader to other references such as technical data, including references to sections and pages within a document (and revision level), that is, “AC 43-13, p.318” or “inspection card 26.2.” Records must be presented to verify times on airframe and engines, inspections, overhauls, repairs, and in particular, time in service, time remaining and shelf life on life limited parts. It is the owner’s responsibility to ensure these records are accurate. Refer to Classic Jet Aircraft Association (CJAA) Safety Operations Manual, rev. 6/30/08.	
45.	AIP Limitations	Refrain from assuming compliance with the applicable military standards, procedures, and inspections are sufficient to achieve an acceptable level of safety for civil operations, as part of the airworthiness certification and related review of the AIP. This may not be true, depending on the situation and the aircraft. For example, an AIP based on 1978 USAF requirements does not necessarily address the additional concerns or issues 35 years later, such as aging, structural and materials deterioration, stress damage (operations past life limits), extensive uncontrolled storage, new techniques, and industry standards.	
46.	AIP Revision Records	Ensure the applicant/operator retains a master list of all revisions that can be reviewed in accordance with other dated material that may be required to be done under a given revision. The AIP should address revision history for manual updates and flight log history.	
47.	Maintenance Responsibilities	Ensure the AIP addresses responsibilities, and functions in a clear manner. The AIP should address the difference between the aircraft owner and operator. The AIP should also address any leasing arrangement where maintenance is spilt or otherwise outside of the control of the applicant, that is, where maintenance is contracted to another party. The AIP should define the person responsible for maintenance. The AIP should address qualifications and delegations of authority, that is, whether the person responsible for maintenance has inspection authority and airworthiness release authority, or authority to return for service. In terms of inspection control and implementation, the AIP should define whether it is a delegation of authority, and if so, what authority is being delegated by the owner and operator. This has been an issue with the NTSB (and the Civil Aeronautics Board before it) since 1957.	
48.	Return to Service	Ensure the AIP clearly defines who can return the aircraft to service and provides minimum criteria for this authority. Follow the intent and scope of § 43.5, Approval for return to service after maintenance, preventive maintenance, rebuilding, or alteration; and § 43.7, Persons authorized to approve aircraft, airframes, aircraft engines, propellers, appliances, or component parts for return to service after maintenance, preventive maintenance, rebuilding, or alteration.	
49.	Maintenance Practices	Consider AC 43.13-2, Acceptable Methods, Techniques, and Practices-Aircraft Alterations, and AC 43.13-1, Acceptable Methods, Techniques, and Practices-Aircraft Inspection and Repair, in addition to any guidance provided by the manufacturer/military service(s), to verify safe maintenance practices.	

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50.	Qualifications for Inspections	Ensure only FAA-certificated repair stations and FAA-certificated mechanics with appropriate ratings as authorized by § 43.3 perform inspections on the aircraft. Contributory factors to the high Luftwaffe loss rate of F-104 Starfighters, (60 lost in accidents in less than 4 years) include poor maintenance due to the Luftwaffe's acute shortage of skilled technicians, and the inexperience of German pilots who have been averaging only fifteen hours per month, with a consequent loss of proficiency.	
51.	Modifications	Verify major changes conform to the applicable guidance (that is, USAF or NATO) and do not create an unsafe condition. Determine whether new operating limitations may be required within the scope and intent of § 21.93. In addition, the information contained in appendix A to part 43 can be used as an aid. Refer to *Potential Reversion Back to Phase I* above.	
52.	Adequate Maintenance Schedule and Program (USAF TO -6-1)	Ensure the AIP follows the applicable requirements, as appropriate (that is, USAF or NATO), concerning inspections. For example, under USAF standards, the proper reference is the most current version of USAF TO 1-F-104-6-1, Aircraft Scheduled Inspection, and Maintenance Requirements. This is important when developing an inspection program under § 91.409. The inspection program must comply with both hourly and calendar inspection schedules. The only modifications to the military AIP should be related to the removal of military equipment and weapons. Deletions should be properly documented and justified. A 100-hour, 12-month inspection program under appendix D to part 43 may not be adequate. Note: The F-104 required about 40 hours of maintenance for every flight hour.	
53.	Airframe, Engine, and Component Replacement Intervals (General)	Verify compliance with required replacement intervals as outlined in appropriate and most current military inspection guidance. If components are not replaced per the military guidance, ask for data to justify extensions. Applicants should establish and record time-in-service for all life-limited components and verify compliance with approved life limits. Set time limits for overrun of intervals and track cycles. Evaluate any overruns of inspection or maintenance intervals.	
54.	Airframe Life-Limit	Verify that the AIP is specific with regards to the airframe life-limit. For example, the USAF discontinued use of the F104A/C after only 11 years, by 1969, and had no need to extend the F-104 airframe life limit. Some F-104 airframes in Europe flew an average of 2,000 hours, but the Canadian Air Force F-104s averaged about 6,000 hours each. If the aircraft is operated beyond the baseline limit, adequate manufacturer/USAF documentation (life limit extension) is required. Typically, this would be covered by the Service Life Extension Program or SLEP.	
55.	Missing Inspection Tasks	Verify the AIP follows the applicable requirements (that is, USAF or NATO) in terms of inspection tasks. It is imperative that no inspection tasks required by the military standard are removed. If they are removed, there should be adequate justification, and removal cannot be solely cost-related. There have been several cases where an AIP did not conform to the applicable military standard and tasks were removed without adequate justification.	
56.	Drag Chute	If the aircraft was originally provided with a drag chute, verify it is installed and the installation follows the applicable USAF guidance and the AIP reflects that installation. There should be adequate technical data to validate any deviations from the original installation.	
57.	Appendix G to 14 CFR Part 23	Recommend appendix G to part 23 be used as a tool (not a requirement) because it can assist in the review of the applicant's proposed AIP and associated procedures. It also sets a good baseline for any review. USAF/NATO technical guidance should also contain instructions for the continued airworthiness of the aircraft. Appendix G to part 23 covers instructions for continued airworthiness.	
58.	Prioritize Maintenance Actions	Recommend the adoption of a risk management system that reprioritizes high-risk maintenance actions in terms of (a) immediate action, (b) urgent action, and (c) routine action. Also refer to *Recordkeeping, Tracking Discrepancies, and Corrective Action* and *Use of Operational Risk Management (ORM)* below.	
59.	Cannibalization	Cannibalization is a common practice for several former military aircraft operators and service providers. This has been documented in civil F-104s operating in the United States. The extent to which it takes place is not necessarily an issue, but keeping adequate records of the transfers, uses, and condition is. In 2001, the U.S. Government Accountability Office (GAO) published its findings on cannibalization of aircraft by the DOD. It found cannibalizations have several adverse impacts. They increase maintenance costs by increasing workloads and create unnecessary mechanical problems for maintenance personnel. The GAO also found, with the exception of the Navy, the services do not consistently track the specific reasons for cannibalizations. In addition, a U.S. Navy study found cannibalizations are sometimes done because mechanics are not trained well enough to diagnose problems or because testing equipment is either not available or not working. Because some view cannibalization as a symptom of spare parts shortages, it is not closely analyzed, in that other possible causes or concerted efforts to measure the full extent of the practice are not made.	
60.	Recordkeeping, Tracking Discrepancies, and Corrective Action	Check applicant recordkeeping. The scope and content of §§ 43.9, 43.11, and 91.417 are acceptable. Recommend the use the USAF Form 781 process (or Naval Air Systems Command (NAVAIR) Maintenance Action Form, or Royal Air Force Form 700) to help verify an acceptable level of continued operational safety (COS) for the aircraft. Three types of maintenance discrepancies can be found inside USAF Form 781: (1) an informational, that is, a general remark about a problem that does not require mitigation; (2) a red slash for a potentially serious problem; and (3) a red "X" highlighting a safety of flight issue that could result in an unsuccessful flight and/or loss of aircraft—no one should fly the aircraft until the issue is fixed. For more information on recordkeeping, refer to AC 43-9, Maintenance Records.	

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61.	Qualifications of Maintenance Personnel	Check for appropriate qualifications, licensing, and type-specific training of personnel engaged in managing, supervising, and performing aircraft maintenance functions and tasks. The NTSB has found using non-certificated mechanics with this type of aircraft has been a contributing factor to accidents. Only FAA-certificated repair stations and FAA-certificated mechanics with appropriate ratings as authorized by § 43.3 perform maintenance on this aircraft.	
62.	Ground Support, Servicing, and Maintenance Personnel Recurrent Training	Recommend regular refresher training be provided to ground support, servicing, and maintenance personnel concerning the main safety issues surrounding servicing and flight line maintenance of the F-104. Such a process should include a recurrent and regular review of the USAF TO warnings, cautions, and notes listed in the appropriate technical manuals. Note: Ejection seat safety is paramount.	
63.	Parts Storage and Management and Traceability	Recommend establishing a parts storage program that includes traceability of parts. This is important in many cases because there may be no original equipment manufacturer (OEM) support.	
64.	Maintenance Records and Use of Tech Data	Conduct a detailed inspection of maintenance records, as required by FAA Order 8130.2. Verify maintenance records reflect inspections, overhauls, repairs, time-in-service on articles, and engines. Ensure all records are current and appropriate technical data is referenced. This should not be a cursory review. Maintenance records are commonly inadequate or incomplete for imported aircraft. If the history of a life-limited component cannot be documented, it must be assumed to have reached its time/cycle limit.	
65.	Airframe Limitations and Durability	Verify whether the AIP addresses the aircraft's airframe limits, how total time is kept, and the status of any extension. Verify the appropriate data is available to consider an extension past the life limit for the airframe and wings.	
66.	"On Condition" Inspections	Adhere to the military/manufacturer program and/or provide adequate data to justify that practice for the applicable part or component if "on condition" inspections are considered. "On condition" must reference an applicable standard (that is, inspect the fuel pump to an acceptable reference standard, not just "it has been working so far"). Each "on condition" inspection must state acceptable parameters. "On condition" inspections are not appropriate for all parts and components.	
67.	Aging	Verify the AIP addresses the age of the aircraft. This means many, if not all, of the age effects have an impact on the aircraft, including: (1) dynamic component wear out, (2) structural degradation/corrosion, (3) propulsion system aging, (4) outdated electronics, and (5) expired wiring.	
68.	Use of Cycles (General)	Recommend the AIP provides for tracking cycles, such as airframe and engine cycles, in addition to time (that is, in hours) and in combination with inspections. This allows for the buildup of safety margins and reliability. In military jet aircraft, there is a relationship between parts failures, especially as they relate to power plants, landing gears, and other systems, and for that reason it is very important to track airframe and engine cycles between failures and total cycles to enhance safety margins. For example, tracking all aircraft takeoffs for full-thrust and de-rated thrust takeoffs as part of the inspection and maintenance program would be a good practice and can assist in building up reliability data. The occurrence of failures can be meaningfully reduced, and cycles can play an important role. When rates are used in the analysis, graphic charts (or equivalent displays) can show areas in need of corrective action. Conversely, statistical analysis of inspection findings or other abnormalities related to aircraft/engine check and inspection periods requires judgmental analysis. Therefore, programs encompassing aircraft/engine check or inspection intervals might consider numerical indicators, but sampling inspection and discrepancy analysis would be of more benefit. A data collection system should include a specific flow of information, identity of data sources, and procedures for transmission of data, including use of forms and computer runs. Responsibilities within the operator's organization should be established for each step of data development and processing. Typical sources of performance information are as follows, however, it is not implied that all of these sources need be included in the program nor does this listing prohibit using other sources of information: • Pilot reports, • In-flight engine performance data, • Mechanical interruptions/delays, • Engine shutdowns, • Unscheduled removals, • Confirmed failures, • Functional checks, • Bench checks, • Shop findings, • Sampling inspections, • Inspection discrepancies, and • Service difficulty reports.	

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69.	Inspect and Repair as Necessary (IRAN)	If an F-104 IRAN is utilized, verify it is detailed and uses adequate technical data (that is, include references to the USAF TO) and adequate sequence for its completion if it is proposed. An IRAN must have a basis and acceptable standards. It is not analogous to an "on condition" inspection. It must have an established level of reliability and life extension. An IRAN is not a homemade inspection program.	
70.	Luftwaffe Centralized Maintenance Program	Recommend that the AIP incorporate the benefits of the German Luftwaffe (Air Force) system of centralized maintenance which was introduced to reduce accidents. Chang introduced at unit level were: o Centralized maintenance operations center; o Introduction of modern communication equipment; o Improved training of line engineers; o Centralized statistics in respect to aircraft defects and maintenance work; o Technical debriefing by pilots after flight;	
71.	Combining Inspection Intervals into One	Set time limits for overrun (flex) of inspection intervals in accordance with the applicable guidance (that is, USAF or NATO).	
72.	Aircraft Storage and Returning the Aircraft to Service After Inactivity	Verify the applicant has a program to address aircraft inactivity and specifies specific maintenance actions for return to service per the applicable inspection schedule(s) (for example, after 31 days). The aircraft should be housed in a hangar during maintenance. When the aircraft is parked in the open, it must be protected from the elements, that is, full blanking kit and periodic anti-deterioration checks are to be carried out as weather dictates.	
73.	Specialized Tooling for Maintenance	Verify adequate tooling, jigs, and instrumentation are used for the required periodic inspections and maintenance per the maintenance manuals.	
74.	F-104 Maintainers Differences Training	Recommend the applicant/operator provide (in the AIP or SOPs) for differences training between F-104 versions and variants for all maintainers and personnel involved in servicing the aircraft. Significant differences include engine, external loads, wiring, instrumentation, and ejection seat.	
75.	Technical Orders Issued While in Service	Verify the AIP references and addresses the applicable technical guidance issued for the F-104 during military service to address airworthiness and safety issues, maintenance, modifications, updates to service instructions, and operations of the aircraft. For example, in cases involving ex-Italian Air Force F-104S/ASA/ASA-M, the data must be dated 2006, the year the aircraft was retired from service in that air force.	
76.	Safety Supplements	Verify the applicant/operator has copies of the applicable safety supplements for the specific version and variant of the F-104 and they are incorporated into the AIP or operational guidance as appropriate.	
77.	Corrosion Due to Age and Inadequate Storage	Ask whether a corrosion control program is in place. If not, ask for steps taken or how it is addressed in the AIP. Evaluate adequacy of corrosion control procedures. Age, condition, and types of materials used in many former military aircraft require some form of corrosion inspection control. Recommend using TO 1-1-691, Corrosion Prevention and Control Manual.	
78.	Pylons (Structural)	Verify the AIP addresses the inspection of the aircraft's centerline and wing pylons per the applicable guidance (that is, USAF or NATO) from a structural standpoint, including checking them for cracks. For example, while early F-104s only had provisions for centerline pylons, other models, notably the F-104G, had wing pylons. The Italian F-104S models added a pair of fuselage pylons beneath the intakes available for conventional bomb carriage. The F-104S had an additional pylon under each wing, for a total of nine pylons.	

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79.	F-104 and J-79 Variants	Verify version of J-79 installed. F-104 aircraft used one of 7 different versions of J-79 engines depending on where the aircraft was manufactured. For example, the J79-GE-3 was used in the YF-104A, F-104A. The J79-GE3A in F-104B. The J79-GE-3B was also installed in the F-104A and F-104B, while the J79-GE-7A was installed in the F-104C, F-104D and F-104F. The J79-OEL-7 was a licensed production GE-7 manufactured by Orenda Engines to power the Canadair CF-104. The J79-GE-11A was found in the F-104G and TF-104G. Many -11 engines were licensed manufactured in Europe as part of the large F-104 consortium production programs, Alfa Romeo, Fiat and Fabrique Nationale being the main suppliers. In addition, the J79-IHI-11A was licensed and production GE-11A, built in Japan by Ishikawajima-Harima Heavy Industries Co., Ltd to power their similarly licensed built F-104J and F-104DJ Starfighters. The J79-GE-19 was installed in Aeritalia F-104S and also retrofitted to some F-104As. Note: The F-104C and F-104D (2 seater) began to reach USAF squadrons in September 1958, and was powered by a General Electric J79-GE-7 engine rated at 10,000 lb. dry and 15,800 lb. with afterburner. This thrust was almost a thousand pounds greater than the -3A/3B of the F-104A/B. This increase in power was made possible by increasing the diameter of the turbine by 3 inches. The J79-GE-7 engine was involved in forty serious mishaps over a 5 year period resulting in 24 lost aircraft and 9 fatalities.	
80.	J79 Engine Maintenance Procedures	Verify the AIP adheres to the maintenance procedures requirements per the applicable J79 engine guidance. It must include the guidance in the most current version of *Consolidated Major Accessories Manual, for J79-GE-7, -11, and 11A Turbojet Engines*, from General Electric, 1 March 1962.	
81.	Manufacturer's and/or USAF J79 Engine Modifications	Verify the AIP addresses the incorporation of the manufacturer and military modifications to the J79 engine installed. The NTSB and some foreign CAAs have determined a causal factor in some accidents is the failure of some civil operators of former military aircraft to incorporate the manufacturer's recommended modifications to prevent engine failures.	
82.	Cycles and Adjustment J79 Engine Replacement Intervals	Ask if both engine cycles and hours are tracked. If not, recommend it be done.	
83.	Failures and Failure Modes	Verify the AIP discusses the known J79 engine failure and failure modes. Engine failures was the cause of many F-104 accidents throughout its operational use. Early GE-J79-3A engines had serious flaws. They were prone to frequent engine failures, flame-outs, compressor stalls, roughness, backfires, and ignition failures which occurred at take-off and at low levels. The early J79 variants were prone to engine failures; but it was quickly replaced when the -3B became available. These engine problems resulted in the grounding of all F-104As in April of 1958 after only a few months of service. Most of the failures were traced to problems with the J79's variable afterburner nozzle. When the afterburner was turned on, it would often get stuck in the open position after it was turned off, which restricted engine power to not much above idle thrust, which was insufficient to maintain level flight, forcing the pilot to make a hasty exit from the aircraft. A more reliable version of the J79, the -3B was developed and retrofitted into existing F-104As beginning in April of 1958. The F-104As were returned to flight status in July of 1958. Other failure modes include: • T-2 reset, and • Un-commanded opening of the variable thrust nozzle.	
84.	J79 Engine Components Life Limits	Verify the AIP addresses the life limit of J79 engine components. "On condition" inspections are not acceptable.	
85.	J79 Engine Inspections and Time Between Overhaul (TBO)	Verify the applicant has established the proper inspection intervals and TBO/replacement interval for the specific J79 engine type and adhere to those limitations and replacement intervals for related components. Justification and FAA concurrence is required for an inspection and TBO above those set in the appropriate aircraft/J79 engine inspection guidance. Clear data on TBO/time remaining on the J79 engine at time of certification is critical, as is documenting those throughout the aircraft life cycle.	
86.	J79 Engine Check	Verify the AIP includes adequate procedures (that is, USAF or NATO), including checks and signoffs for returning an aircraft to airworthiness condition after any work on the J79 engine. As an example, as part of its investigation of a fatal former military aircraft accident in 2004, the NTSB found after an engine swap-out the week before the fatal accident, the mechanics had warned the newly installed engine was not operating correctly. The record also shows the A&P mechanic who oversaw and supervised the engine change did not sign off any maintenance records to return the airplane to an airworthy status. Before the fatal flight, two engine acceleration tests failed, and multiple aborted takeoffs took place in the days leading up to the crash.	
87.	J79 Engine Thrust	Verify the AIP includes measuring actual thrust of the J79 engine and tracking engine operating temperatures.	

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88.	Afterburners and Nozzle	Verify the AIP specifically addresses the inspection of the afterburner system and the augmentor nozzle and related actuators. Afterburner failures have been the cause of many F-104 accidents. For example, there was a spate of nozzle failures in the J79 engine fitted to the F-104C. It was found that the nozzles, being operated by the engine oil system, were failing to open or close due to sludge on the oil filters. The system was changed so that the nozzles were controlled by the engine fuel system and the problem was rectified. Refer to *Variable Thrust Nozzle* below.	
89.	Variable Thrust Nozzle	Verify the AIP specifically addresses the un-commanded opening of the variable thrust nozzle (usually through loss of engine oil); although the engine would be running normally at high power, the opening of the nozzle results in a drastic loss of thrust. A modification program installed a manual nozzle closure control that reduced the problem. Note: An adjustable exhaust nozzle incorporated slatted vanes that opened and closed, depending on throttle, to give the most efficient thrust and specific fuel consumption. The nozzle is placed in the closed position for military thrust (full thrust without A-B) and transitions to the full open position during A-B use. A malfunction in the nozzle system would cause the nozzle to move to its full open position, resulting in a severe loss of thrust. Many aircraft were lost on take off and in other flight modes when the A-B failed and/or the nozzle opened while not in A-B and the pilot lost control of the aircraft. There is an emergency T-handle in the cockpit which allows the pilot to close the nozzle (connected to the nozzle by a flexible cable) in case of closure failure.	
90.	Use of Different Fuels	Verify the AIP addresses how using different fuels may require changes or additions to the J79 engine inspection and maintenance programs. This ranges from JP-4 (Naphtha-based fuel) used earlier on by the USAF to JP-8 and Jet-A (Kerosene-based fuel) more recently.	
91.	J79 Engine Ground Run	Verify the engine goes through a ground run and check for leaks after reassembly. Confirm it achieves the required performance parameters, that is, exhaust gas temperature, outside air temperature, and field elevation.	
92.	Asymmetric Flaps	Verify the AIP specifically addresses the inspection of the flap system per the applicable USAF guidance. Several F-104s have been lost due to flap malfunctions.	
93.	Leading Edge Slats	Verify proper slat condition and functionally (that is, lubrication, freedom of movement, and realignment). Asymmetric flap deployment was another common cause of accidents.	
94.	Boundary Layer Control System (BLCS)	Verify the AIP addresses the inspection of the BLCS per the applicable USAF TO. The BLCS, or "blown flaps," was incorporated into the F-104 to address high landing speeds. It works by bleeding engine air over the trailing-edge flaps to energize airflow and thus improve lift. The system was a boon to safe landings, although it proved to be a maintenance problem in service, and landing without the BLCS could be a harrowing experience.	
95.	Fire Detection and Suppression System	Verify the serviceability of the fire detection and suppression system. The operator should establish an inspection process (reference the appropriate technical guidance) to ensure the validity of the fire warning system.	
96.	Servicing, Engine Fire Servicing Personnel Unfamiliar with the Aircraft Create Hazardous Situations	Ensure the operator warns servicing personnel via training and markings of the fire hazard of overfilling oil, hydraulic, and fuel tanks. Lack of experience with the aircraft servicing is a safety concern. Require supervision of servicing operations and fire safety procedures.	
97.	Fire Guard	Verify maintenance, servicing, preflight, and post-flight activities include fire guard precautions. This is a standard USAF/NAVAIR safety-related procedure.	
98.	J79 Engine Start	Verify the AIP includes procedures for documenting all unsuccessful starts. Failure to take into account engine start deficiencies (including not following the applicable Technical Orders) has been the cause of many F-104 engine failures. Note: An external AIR starting unit is required for starting the J-79 engine. A small starter turbine is located on the front frame of the engine and in front of the Inlet Guide Vanes (IGV). AIR drives the starter turbine, air pressure connects the starter turbine to the engine main shaft, and rotation occurs. Air also provides enough mass airflow through the engine so that at 12% RPM, the throttle can be opened and enough total mass airflow is available to keep the resulting fire from touching the sides of the burner cans and prevents damage to the engine and over heat. Electricity is not required to rotate the engine on start-up. At 40% RPM, the external air is removed from the starter turbine.	
99.	J79 Engine Storage	Review J79 engine storage methods and determine engine condition after storage. Evaluate calendar time since the last overhaul. For example, using an engine with 50 hours since a 1991 overhaul may not be adequate and a new overhaul may be required after a specified time in storage. Note: Experience has shown that former military aircraft, engines that have exceeded storage life limits are susceptible to internal corrosion, deterioration of seals and coatings, and breakdown of engine preservation lubricants.	

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100.	Wiring Diagram and Inspection	Verify the AIP includes up-to-date wiring diagrams consistent with the appropriate guidance (that is, USAF or NATO) and includes the appropriate inspection procedures. Any reference to the applicable guidance must address modifications. In addition to the appropriate guidance, another reference is NAVAIR NA 01-1A-505, Joint Service General Wiring Maintenance Manual.	
101.	Engine Foreign Object Damage (FOD)	Verify adoption of an FOD prevention program (internal engine section, external, and air intake). Use and properly inspect the air intake screen (FOD guards) provided with the aircraft and designed for the aircraft. The following incident narrative by a Canadian CF-104 pilot illustrates this: "…I taxied out in aircraft 104658 en-route to Denmark for a "dirty weekend." I planned a burner climb to Flight Level 230. The weather was about 1500 feet and 3 miles in haze. We (2 seat aircraft, TF-104G) had a full fuel load with pylon tanks and the takeoff and clean-up went by the book. As we passed through 14,000 feet, still in burner, and just prior to the right turn that brings you back overhead, a large bang was heard, a noticeable loss of thrust was felt, and to my horror, the EGT was pegged past 1000° C. My immediate reaction was to pull the throttle to idle and turn left back towards the base. At idle power the engine instruments were normal, and while I felt certain that we had experienced a compressor stall for which the checklist calls for engine shut-down, I believed that since the indications were now normal that action would be somewhat imprudent. I then advanced the power towards 100% and the engine stalled again at 86%. Mean while I was talking to radar, had the TACAN needle slightly offset to the left and established my gliding speed at 260 kts with takeoff flap. This produced a rate of descent of approximately 3200 feet per minute, and any further back pressure on the stick to decrease this only cause a rapid decrease in airspeed and increase in the rate of descent. I was not a happy camper. On reduction to idle power, once again, the engine cleared itself to normal parameters. This time, I advanced the power to 85% and left it there. It held for about two to three minutes and then the compressor stalled again. I advised radar that I would have to jettison my tip and pylon tanks … and then jettisoned the tanks. The engine compressor stalled again and I set 82% which held for the time being. With the departure of the fuel tanks, the rate of descent ease off somewhat to between 2500 and 2800 feet per minute. When I visually saw the runway, I felt confident that we were in a good position and I planned an initial touch-down point of half way down the runway. As I started the turn to final, I felt stick shaker and initially thought, "No problem, it's just the dual." Then I quickly realized that we no longer had fuel tanks and therefore the stick shaker indication was valid. Because my height seemed more than adequate, I decided to lower the gear and it came down without any problem. I continued the turn on light stick shaker and realized that while our height was good, I would not be able to make the turn to line up with the runway. The only option I could think of to use Land flap, which I then selected. The good news was that it worked beautifully, the stick shaker went away, and the turn rate increased so that I was able to line up with the approach end of Runway 22. The bad news was that the added drag increased my rate of descent tremendously and I could see that we were going to hit short. I then automatically fire-walled the throttle and low and behold, it worked! We touched down about 12 inches past the threshold, much to my delight. The technical explanation was because Land flaps have boundary layer flow, which utilizes bleed air from the 17th stage of the compressor, this allowed the engine to operate without another compressor stall. The trip was 15 minutes long. The final investigation showed that a 5/8" bolt had trashed the engine. However, it was not from the aircraft. The checklist was also revised to reflect that if the engine clears at idle after a compressor stall, do not shut the engine down, and attempt a re-light." Bashow, 1990.	
102.	J79 Engine Condition Monitoring (Oil Analysis)	Recommend an engine Spectrographic Oil Analysis Program (SOAP) be implemented with intervals of less than 15 hours as part of the engine maintenance schedule. If baseline data exists, this can be very useful for failure prevention. If manufacturer baseline data does not exist, this may still warn of impending failure. For the latest guidance on SOAPs affecting the particular J79 engine, refer to Joint Oil Analysis Program Manual, Volume III: Laboratory Analytical Methodology and Equipment Criteria. (Aeronautical), (Navy) NAVAIR 17-15-50.3, (Army) TM 38-301-3, (Air Force) TO 33-1-37-3, and (Coast Guard) CGTO 33-1-37-3, dated July 31, 2012. This document presents the methodology for evaluating spectrometric analyses of samples from aeronautical equipment. The methodology enables an evaluator to identify where metals present in the sample and their probable sources, judge equipment condition, and make recommendations that influence maintenance and operational decisions. Following these recommendations can enhance safety and equipment reliability and contribute to more effective and economic maintenance practices.	
103.	Engine Bleed Air	Verify the AIP includes procedures for inspecting and ensuring the serviceability of the J79 engine bleed air system.	
104.	Fuel Tank Inspections and Related Structures	Verify the AIP includes procedures for inspecting the fuel tanks (and related structures). Deterioration of bladder tank (bag) and the sealant can pose a safety problem, especially because of the aircraft's age and storage, as well as the difficulty of the inspection (and access to the fuel tanks) itself. Bladder-type fuel tank safety is not necessarily ensured by only "on condition" inspections and may require more extensive processes, including replacements. In any event, adequate data must be provided for any justification to inspect rather than replacing the fuel tanks at the end of their life limit.	

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105.	Hydraulic Problems	Verify the AIP emphasizes the hydraulic system. This is a known problem with the aircraft. The F-104 Starfighter had two independent hydraulic systems, in addition to an emergency system. Its components and specifications include: one emergency system (RAT), two variable displacement pumps, a hydraulic system pressure of 3,000 PSI, a closed center system, a Type II hydraulic system / -65 to 275 degrees Fahrenheit, fluid specification MIL-PRF-5606H, an accumulator pre-charge of 800-1,000 PSI. As with many aircraft of its generation, is prone to failure. Both normal and emergency hydraulic systems in the F-104 are important safety items. Hydraulic failures were typically associated with flight control issues. Ensure that the AIP provides for the correct inspection procedures for the hydraulic system and address things like completely flushing the hydraulic system when a pump is replaced. Consider expanding upon the USAF/NATO inspection guidelines for the hydraulic system(s) by adopting more frequent inspection and replacement times. USAF operational experienced shows that cold weather situations needs to be addressed in servicing as hydraulic system seal shrinkage was common, leading to leaks. This can be emphasized in the AIP and in the emergency procedures. Note: The following illustrates the aircraft's hydraulic system: **"# 1 Hydraulic System** - 3,000 psi • Aileron Actuators; • Stabilizer Actuators; • Yaw Damper Control Valve; • The Autopilot actuators for the ailerons and stabilizer, the auto pitch actuator, and the yaw damper control valve are powered by this system. Autopilot won't engage below 1,250 psi. A low pressure warning illuminates below that value. **Emergency Hydraulic System** The emergency hydraulic system, as it is called, consists of a ram air turbine that may be extended by the pilot in the event the # 1 hydraulic system pressure s lost. This ram air turbine powers a hydraulic pump that takes fluid from the # 1 Hydraulic Reservoir, and pressurizes the # 1 Hydraulic System as long as the ram air turbine is up to operating rpm. This is the same ram air turbine that powers the emergency generator. It only powers flight controls. **# 2 Hydraulic System** - 3,000 psi • Flight Controls; • Constant Frequency AC Generator; • Pitch & Roll damper control valves. **Unpowered below 2,175 psi. If unpowered:** • Landing Gear *Manual Gear Extension;* • Normal Brakes *Manual Brakes;* • Anti-Skid *Inoperative;* • Nose wheel Steering *Diff Braking & Rudder;* • Engine Air by-pass Flaps *Fails in last position;* • Speed brakes *Fails in last position*; • Denotes "Utility" items. If # 2 Hydraulic System pressure drops below 2,175 psi these items become unpowered such that the remaining pressure powers the flight controls and the Constant Frequency 400 cycle AC Generator." Source: http://www.airplanedriver.net/study/f104.htm	
106.	Control Valves and Hydraulic Fuel Contamination	Verify the AIP emphasizes the control valves. For example, a fatal accident occurred when a CF-104 rolled inverted on short final, giving the pilot no chance to bail out. A very persistent Board determined that the aircraft's control valves exhibited microscopic scoring from hydraulic-fuel contamination. These valves were slotted, pencil-like rods which received control inputs from the pilot and ported 3,000 psi hydraulic fluid to the control surface actuators. If they began to seize due to scoring, un-commanded control surface and control column movements were the result. It turned out that these valves had been accorded a 1,000-hour life by the manufacturer, but the RCAF had removed the life limit. There were none in the supply chain and it took about a year to acquire and replace all the valves in the fleet. The pilots were told and there were more than a few aborted missions over the ensuing year when an aircraft seemed to have developed a mind of its own during flight.	

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107.	Broken Systems (Fuel, Oil, and Hydraulic) Lines	Verify the AIP includes procedures for inspecting and replacing fuel, oil, and hydraulic lines according to the applicable USAF requirements; for example, MIL-DTL-8794 and MIL-DTL-8795 specifications.	
108.	Systems Functionality and Leak Checks	Verify procedures are in place to check all major systems in the aircraft for serviceability and functionality. Verify the leak checks of all systems are properly accounted for in the AIP per the military (that is, USAF or NATO) requirements.	
109.	Oil, Fuel, and Hydraulic Fluids	Verify procedures are in place to identify and use a list of equivalents of materials for replacing oil, fuel, and hydraulic fluids. Many operators include a cross-reference chart for NATO and U.S. lubricants as part of the AIP.	
110.	Ram Air Turbine (RAT)	The AIP and associated procedures need to emphasize the inspection of the system and the dangers of the RAT to ground crew. Besides the fact that the RAT requires specific maintenance attention, maintenance crews had to stay alert when working on the F-104. Note: Once the RAT is deployed in flight, it can only be retracted by ground crews. The RAT, when deployed, drives the 4.5 kW 115 volt 400 cycle generator, as well as an emergency hydraulic pump. If all other generators fail, the RAT will power the emergency AC bus, primary fixed frequency AC bus, and through a 20 amp transformer rectifier, both emergency DC busses and the battery busses. The emergency AC bus will not power the fixed frequency AC bus as long as the hydraulic driven generator is operating.	
111.	CFG	Verify that the AIP focus on the inspection and service of the CFG, or Constant Frequency Generator. This includes in making sure that the inspection cards for the system are incorporated as well as daily before flight checks. Its replacement, as per T.O. 1F-104-6 also needs to be covered. This is a critical component. In the F-104, the constant frequency 400 cps 115 volt AC generator is driven by the #2 hydraulic system. It can operate down to about 20% engine rpm. It provides power to the items that require constant frequency AC power. These items are on the primary and secondary fixed frequency busses. If the constant frequency generator fails, the busses will be powered from the emergency AC bus. In the event both main generators and the constant frequency generator fail, the secondary fixed frequency AC bus will be un-powered.	
112.	Electrical System and Batteries	Verify functionality of the generator and the compatibility of the aircraft's electrical system with any new battery installation or other system and component installation or modification. Avoiding overload conditions is essential because this is a known problem with the aircraft's electrical system.	

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113.	Buses	Verify that the AIP specifically addresses the required inspections and testing of all electrical system's busses. The following illustrates the complexities of the system and the need to ensure functionality of those systems retained in civil use. **"Emergency AC Bus:** In order for the Emergency AC Bus to be powered you must have one of the main generators, or the emergency generator on line. This bus does not load shed unless both engine driven generators and the emergency generator are INOP. It operates the (1) Leading Edge Flaps # 3 Fuel Boost Pump, (2) Training Edge Flaps` UHF Comm. & TACAN, and (3) Windshield Defog Transponder. **# 1 Emergency DC Bus:** In order for the # 1 Emergency DC Bus to be powered by the primary DC bus, (gets it's power from the 120 amp transformer rectifier), you must have one of the main generators on line. Otherwise, it is powered by the Emergency AC bus through a 20 amp transformer rectifier and the # 1 Emergency DC bus power relay. The # 1 Emergency DC Bus is un-powered when the flaps are operated during emergency electrical system operation. The items listed below are powered by the # 1 Emergency DC bus. It operates: (1) Landing Gear Indication Trim Control, (2) Landing Gear Warning Warning Lights (Except Fire), (3) Landing Gear Control Rain Removal System, (4) Rudder Limit Control Windshield Defogger, (5) Speed Brakes Canopy Audio Warning, (6) Stick Shaker Canopy Seal, (7) Fuel Quantity Gauges External Tank Transfer, (8) Hot Air Shutoff, and (9) Transponder. **# 2 Emergency DC Bus:** Number 2 Emergency DC Bus is powered by the # 2 AC Bus through the 120 amp transformer rectifier. If # 2 AC is not powered, the Emergency AC Bus powers it through the 20 amp transformer rectifier. Only two items are on this bus, (1) Leading Edge Flaps and (2) Trailing Edge Flaps. **# 1 Primary AC Bus:** In order for the # 1 Primary AC Bus to be powered you must have only one main generator on line. The inertial navigation heater is the only item on this bus. This is of little concern, as the INS will have most likely been removed and replaced with a smaller and lighter GPS unit, or just a Rolex and a compass. **Primary DC Bus:** The primary DC bus is powered by the # 2 AC Bus through the 120 amp transformer rectifier. During normal operations, it in turn powers the # 2 Emergency DC bus. It operates: (1) Air Data Computer Seat Actuator, (2) Auto Pilot Cockpit Spotlights, (3) Nav Lights Duct Anti – Ice, (4) Electronic Equipment Test Engine Air by-pass Flaps, (5) Taxi Light Engine Inlet Air Temp, (6) Radar Accelerometer, and (7) Voice Recorder Radar Dehydrator. **# 1 Secondary AC Bus:** Powered by main AC generators if they are both operating and on line. It powers (1) # 1 Fuel Boost Pump Intake Duct Anti - Ice and (2) # 4 Fuel Boost Pump Transfer Pump. **# 2 AC Bus:** Powered if at least one of the main AC generators are operating and on line. Loss of both main generators will render this bus un-powered. It powers: (1) Afterburner Ignition Optical Sight, (2) Air Conditioning Oxygen Indicator, (3) Anti - Icing Valve Pitot & AOA Probes, (4) # 2 Fuel Boost Pump Auto Transformer for LDG Lights, and (5) CIT Warning System Radar System. **Primary Fixed Frequency AC Bus: This bus covers: (1)** Afterburner Nozzle Indicator Cockpit Panel Lights, (2) Auto Pitch Control Cockpit Flood Lights, and (3) C-2G Compass Standby Attitude Indicator Instrument Power Transformer TACAN & IFF. **Secondary Fixed Frequency AC Bus:** This bus is load shed if power to the # 2 AC Bus is lost. Loss of both main generators will make this happen. It powers: (1) Air Data Computer Stability Augmenters, (2) Auto Pilot Fuel Indicators, (3) Radar System Voice Recorder **# 1 Battery Bus:** Powered by the Emergency AC Bus through the 20 amp transformer rectifier or by the # 1 battery. It powers: (1) Engine Start # 1 External Power Control External Stores Release Fuel Shutoff, (2) ENCS Emergency UHF Radio, (3) Anti - Skid Nose wheel Steering, and (4) Engine Oil Low Warning Special Stores Drop # 1. **# 2 Battery Bus:** Powered by the Emergency AC Bus through the 20 amp transformer rectifier or by the # 2 battery. It covers: (1) Engine Start # 2, (2) External Stores Emergency Release, (3) External Tank Refueling Fire Warning System, (4) Arresting Hook Main Generator Reset, (5) and ENCS Special Stores Drop # 2." Source: http://www.airplanedriver.net/study/f104.htm.	

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114.	Borescope J79 Engine	Recommend the AIP incorporate borescope inspections of the engine at 50 hours per the applicable inspection procedures. AC 43.13-1 can be used as a reference.	
115.	Pitot/Static, Lighting, and Avionics and Instruments	Verify compliance with all applicable 14 CFR requirements (that is, § 91.411) concerning the pitot/static system, exterior lighting (that is, adequate position and anti-collision lighting), transponder, avionics, and related instruments.	
116.	Pitot Tube	Verify the AIP addresses the proper inspection of the pitot tube system.	
117.	Oxygen System (General)	Emphasize inspection of the oxygen system and any modifications. Compliance with § 91.211, Supplemental Oxygen, is required. Recommend adherence to § 23.1441, Oxygen Equipment and Supply. Moreover, per FAA Order 8900.1, change 124, chapter 57, Maintenance Requirements for High-Pressure Cylinders Installed in U.S. Registered Aircraft Certificated in Any Category, each high-pressure cylinder installed in a U.S.-registered aircraft must be a cylinder manufactured and approved under the requirements of 49 CFR, or under a special permit issued by the Pipeline and Hazardous Materials Safety Administration (PHMSA) under 49 CFR part 107. There is no provision for the FAA to authorize "on condition" for testing, maintenance, or inspection of high-pressure cylinders under 49 CFR (PHMSA).	
118.	LOX O2 Quality	Ask whether the aircraft is equipped with a LOX O2 system. If it is, verify the AIP incorporates a quality inspection of the LOX O2 used in the system. This is because there were reported cases of the LOX system malfunction affecting pilot's breathing capabilities. German Air Force experienced oxygen contamination problems with their Lockheed F-104G Starfighter jets in the late 60s - early 70s. Contamination of the oxygen caused loss of consciousness of the pilots on multiple occasions. Note: Ask applicant/operator to consider whether converter failure is also a possibility or if a 100 percent setting is appropriate in certain phases of flight.	
119.	LOX System (Liquid Oxygen System)	Contemplate a gaseous replacement if using of the aircraft LOX system. LOX systems are dangerous and complex (i.e., LOX converter). If used, proper precautions are needed and total adherence to USAF/NATO safety requirements required.	
120.	Oxygen Relief Valve Failures	Verify the AIP incorporates the proper inspection and replacement of oxygen relief valves. This was an operational issue with the aircraft and it is suspected the valves were tuned too soon. The valve had to be set on building up and left there for a while before resetting to the operating position. It was suspected that excess pressure was blowing valves. Note: In the USAF, the oxygen relief valve inspection and replacement was a depot-level item.	
121.	Other Pressure Cylinders	Emphasize the proper inspection of any pressure cylinders. Per FAA Order 8900.1 change 124, chapter 57, each high-pressure cylinder installed in a U.S.-registered aircraft must be a cylinder that is manufactured and approved under the requirements of 49 CFR, or under a special permit issued by PHMSA under 49 CFR part 107. There is no provision for the FAA to authorize "on condition" for testing, maintenance or inspection of high-pressure cylinders under 49 CFR. For example, the fire bottles are time sensitive items, and may have a limit of 5 years for hydrostatic testing. The issue is when the bottles are removed from the aircraft. It is industry knowledge that non-U.S. bottles may be installed as long as they are within their hydrostatic test dates. A problem arises when removing the bottles for hydrostatic testing. Maintenance programs require these bottles to be hydrostatic tested. Once the non-U.S. bottles are removed from the aircraft, they are not supposed to be hydrostatic tested, recharged, or reinstalled in any aircraft. Moreover, those bottles cannot be serviced (on board) after the testing date has expired.	
122.	Anti-G Suit System	Verify the serviceability of both aircraft systems (that is, anti-G valve) and the anti-G suit, if installed. There have been instances of anti-G valves being stuck in the open position. If the anti-G valve fails, it can blow scorching hot air into the cockpit. Note: A G suit, or the more accurately named anti-G suit, is a flight suit worn by aviators and astronauts who are subject to high levels of acceleration force (G). It is designed to prevent a blackout and G-induced loss of consciousness (G-LOC caused by the blood pooling in the lower part of the body when under acceleration, thus depriving the brain of blood. Blackout and G-LOC have caused a number of fatal aircraft accidents.	
123.	Pressurization Vessel and Environmental Control	Verify the AIP incorporates the inspection of the pressurized sections of the aircraft per the appropriate technical guidance (that is, USAF or NATO). Note pressure cycles and any repairs in the area. Verify the AIP incorporates related documentation and manuals. See *Defogger System* below.	
124.	Defogger system	Ensure that the AIP provides for the service the system per the inspection and maintenance manual. The F-104 has a defogger system consisting of a number of small air jets directed parallel to the canopy and windshield surfaces. The jets entrap cockpit air and cause it to flow over the inside surface, thereby raising the surface temperature. As long as the surface temp is above the cockpit dew point, no fog or frost will be formed. Air comes from downstream of the water boiler on the air-conditioning shutoff valve to the defogger outlets located along the inside base of the windshield and electronics hatch transparent surface and in the forward frame of the canopy. The system is augmented by bleed air.	
125.	Cockpit Instrumentation Markings	Verify all cockpit markings are legible and use proper English terminology and units acceptable to the FAA. The AIP should address inspection of all cockpit instruments with regular intervals for each subsystem. Care should also be taken to inspect modifications, including communications, navigation, or other upgrades to the cockpit. The AIP should address a cockpit indicator calibration process to ensure accurate indications for essential components.	

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126.	Caution Light System	Ensure the AIP includes steps to verify and maintain the integrity of the caution light systems in the aircraft.	
127.	Safety Markings and Stenciling	Verify appropriate safety markings required by the technical manuals (that is, stenciling and "Remove Before Flight" banners) have been applied and are in English. These markings provide appropriate warnings/instruction regarding areas of the aircraft that could be dangerous. These areas include intakes, exhaust, air brakes, and ejection seats. In the case of ejections seat systems, and as noted in FAA Order 8130.2, paragraph 4074(e), "a special airworthiness certificate will not be issued before meeting this requirement."	
128.	Cockpit FOD	Verify the AIP addresses thorough inspection and cleaning of the cockpit area to preclude inadvertent ejection, flight control interference, pressurization problems, and other problems. This is a standard USAF/NAVAIR practice.	
129.	Tires and Wheels	Verify use of proper tires and/or equivalent substitutes (including inner tubes) and adherence to any tire limitation, such as allowed number of landings (10 landings on the F-104 for the main tires), and inflation requirements. In the F-104, the type of tire dictates the number of landings. Wheels must be properly and regularly inspected and balanced. Many former military high-performance aircraft have a long history of tire failures, one of the leading causes of accidents. The operator of an F-104 demonstration team in the US noted in 2007 that "even things as seemingly simple as new tires cost $1,000 apiece for these 50-year old aircraft. Each main gear tire is only good for about 10 landings, so that comes to about $100 per landing per tire. You spend $600 every time the three-ship touches down,…so if you're talking about one hop to get there, three hops during the show, and one hop to leave, you've got five landings – so that's $3,000 just for tires." http://www.slideshare.net/Art37/civilian-demo-team-on-f-104-2432062.	
130.	Explosives and Propellants	Check compliance with applicable Federal, State, and local requirements for all explosives and propellants in terms of use, storage, and disposal, in addition to verifying service (USAF) requirements are followed.	
131.	HAZMAT	Recommend the AIP incorporates adequate provisions on HAZMAT handling. Refer to Gamauf, *Handling Hangar Hazmat*, August 2012.	
132.	In-Flight Canopy Separation	Ensure the AIP addresses the proper maintenance and operating condition of all canopy locks.	
133.	Canopy Seals	Test canopy seals for leaks (that is, use ground test connection).	
134.	Transparencies Problems	Ensure proper transparencies maintenance for safe operations. Monitor/inspect canopy for crazing every 10 hours of flight.	
135.	Emergency Canopy Jettison Mechanism	Verify the AIP includes testing the emergency canopy jettison mechanism (on left side of the fuselage and uses the same linkage as the canopy jettison handle to fire the canopy) is functional and properly inspected as per the applicable technical guidance. On TF aircraft, the forward canopy will fire first, the rear canopy approximately 3 seconds later).	
136.	Brake System	Emphasize a detailed inspection of the brake assemblies, adhere to applicable inspection guidelines and replacement times (that is, USAF or NATO), and consider more conservative inspections. Recommend brake inspection at 20 to 30 landings.	
137.	Hoses and Cables	Inspect and replace hoses and cables appropriately. Due to the age of many of the former military high-performance aircraft, and in many cases, poor storage history, it is essential to ensure thorough inspections of all hoses and cables (multiple systems) and replace them in accordance with the guidance and requirements (that is, USAF or NATO).	
138.	Grounding	Verify adequate procedures are in place for grounding the aircraft. Static electricity could cause a fire or explosion, set off pyrotechnic cartridges, or result in any combination of the above. In grounding the aircraft, it is essential that all electrical tools are grounded, and industry-approved explosion-proof flashlights or other lighting sources be used.	
139.	TO 00-25-172	Use TO 00-25-172, Ground Servicing of Aircraft and Static Grounding/Bonding, dated August 2012, as the baseline for all servicing functions. This manual describes physical and/or chemical processes that may cause injury or death to personnel, or damage to equipment, if not properly followed. This safety summary includes general safety precautions and instructions that must be understood and applied during operation and maintenance to ensure personnel safety and protection of equipment.	
140.	Angle of Attack (AOA) System	Ensure the AIP covers the adequate inspection and calibration of the AOA system and AOA indexer if one is originally installed in the aircraft.	

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141.	Antennas	Verify any original antennas are compatible with all installed electronics. In addition, verify the AIP includes the appropriate inspections of the antennas. Some new avionics may impose airspeed limitations. Over the years, many different antennas were installed in this type of aircraft. This is likely to be an issue with the F-104. For the basics on this issue, refer to Higdon, David. Aircraft as Antenna Farm. *Avionics,* Vol. 49, No. 9 (September 2012).	
142.	Hard Landings and Over G Situations	Verify hard landing and over-G inspection programs are adopted and follows the applicable USAF TO. This is especially important when acrobatics are performed or when the aircraft is involved in military support missions outside the scope of its experimental certificate (that is, PAO), and in light of safety concerns with the wing and flight control surface cracks and delamination.	
143.	Wing Connection Fittings	Verify that the AIP addresses the F-104 wing connection fittings which are critical components for which special measures were formulated by Lockheed to be replaced at 1,500 hours. Even so, some airframe inspections have shown cracks before the replacement specification. Note: The wing connection fittings issue includes fitting No. 5, and all are critical components. Operationally, special measures were formulated. The fittings were investigated for initial cracks in the critical hole 12 using a special eddy current method developed by the IABO. In fatigue investigations, initial cracks were detected in a number of fittings before the maximum operational time interval for these components had been reached, which is fixed at 1,500 flight hours (exchange within the framework of the retrofit program).	
144.	Nondestructive Inspection (NDI)	Ensure the AIP provides for all the required NDI or nondestructive testing under the appropriate guidance (that is, USAF or NATO).	
145.	Exhaust Trail Areas	Verify that the AIP includes the proper inspection of the exhaust trail areas. Engine exhaust deposits are very corrosive and give particular trouble where gaps, seams, hinges, and fairings are located downstream from the exhaust pipes or nozzles. For example, "deposits may be trapped and not reached by normal cleaning methods. Pay special attention to areas around rivet heads and in skin lap joints and other crevices. Remove and inspect fairings and access plates in the exhaust areas. Do not overlook exhaust deposit buildup in remote areas, such as the empennage surfaces. Buildup in these areas will be slower and may not be noticed until corrosive damage has begun." http://www.faa.gov/library/manuals/aircraft/amt_handbook/media/faa-8083-30_ch06.pdf.	
146.	Parts Fabrication	Verify engineering (that is, designated engineering representative) data supports any part fabrication by maintenance personnel. Unfortunately, many modifications are made without adequate technical and validation data. AC 43.18, Fabrication of Aircraft Parts by Maintenance Personnel, may be used as guidance.	
147.	Wings and Tail Bolts and Bushings	Ask about inspections and magnafluxing of wings, and tail bolts and bushings. Recommend the AIP incorporate other commonly used and industry-accepted practices involving NDI if not addressed in the manufacturer's maintenance and inspection procedures.	
148.	Horizontal Stab Bearing Inspection and Lubrication	Ask if the AIP includes required inspections and maintenance of the horizontal stab bearings. Failure to properly lubricate/inspect the bearings or improper reinstallation could result in loss/failure of the bearings and in-flight loss of control.	

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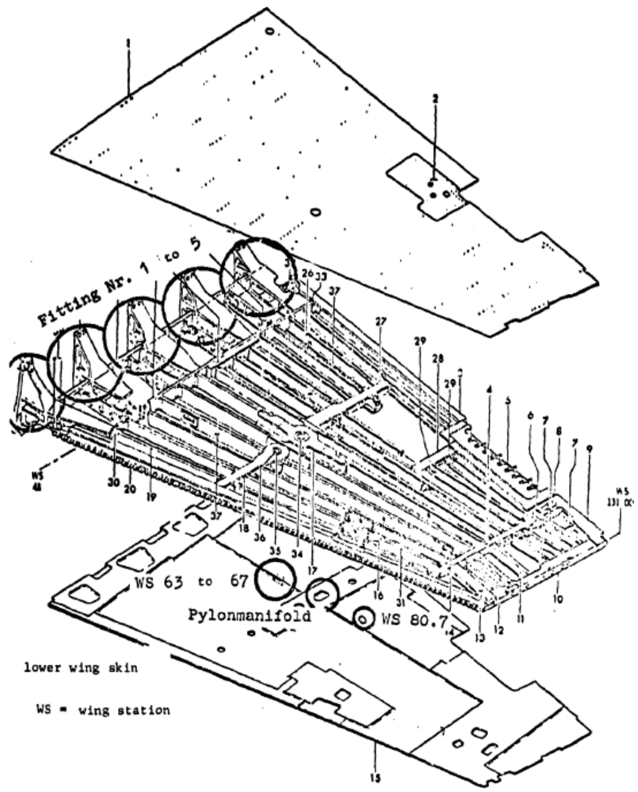
149.	Wing Structural Issues	Verify the AIP incorporates the latest guidance (likely Italian Air Force data from 2006) on the correct inspection and maintenance, including replacement (life limit) of the wing and related structures (especially the spars and wing attach point) per the applicable USAF/NATO requirements (Technical or Engineering Orders) including those addressing changes, fixes and other operational issues. In German Air Force service, the problem of structural failure of the wings emerged. Original fatigue calculations had not taken into account the high number of G-force loading cycles the German F-104 fleet was experiencing, and many airframes were returned for depot maintenance where their wings were replaced, while other aircraft were simply retired. Note: On F-104 G models, the fuselage, wing, and empennage were strengthened to enable the aircraft to carry an increased offensive weapons load and to handle the stresses of low-altitude combat missions flown at high speeds. A total of 36 new forgings were needed to reinforce the fuselage mainframes, wing fittings and beams, fuselage longerons, joints, and tail frames, empennage beams and ribs, plus some fuselage skins. Some reinforcement was made to the trailing-edge flap fittings to allow partial deflections of up to 15 degrees during combat maneuvers, allowing reductions of up to 33 percent in turning radius at altitudes of 5,000 feet. Note: The choice of the straight wing posed severe structural challenges in the F-104. To achieve acceptable supersonic performance, the wing had to be extremely thin (tapering from 4.2 inches deep at the fuselage to 1.96 inches at the tip), with very sharp leading and trailing edges (the leading edge had a nose radius of only 0.016 inches, or 0.041 cm). But the wing also has to be extremely rigid to avoid aileron-induced deflection and consequent control reversal. Lockheed's solution was to use a spar and transverse core machined from a single aluminum slab covered with single-piece, relatively thick (tapering from one-half inch to one quarter inch) upper and lower aluminum skins. The skin was shaped in a compression die, which produced both a very level wing surface and precisely formed rivet holes, which together permitted the extraordinarily smooth surface necessary for efficient supersonic flight. See *F-104 Fatigue Testing* below.  Summary of wing damage	

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150.	F-104 Fatigue Testing	Recommend that the AIP incorporate the relevant findings contained in TOTAL AIRFRAME FATIGUE TEST F 104 G - FINAL REPORT, Foreign Technology Division Wright-Patterson Air Force Base, Ohio, 20 March 1975. This report contains the most important information and "data on the experimental configuration, experimental sequence, and the results of the F-104**G** total airframe fatigue experiment. Details include all the damage information which occurred on the structure during the experiments. This report can be used as a means of orientation for the information contained in the partial reports because of the cross references in the text and the tables-7his final report also contains an evaluation of the most important results (damage) and contains recommendations for their elimination, as well as modifications already made."	
151.	Lower Wing Skins	Verify the AIP incorporates the latest guidance concerning the inspection (for damage) in the lower skin of the wing assembly in the region of the aileron servo (this has been documented in fatigue testing) and which led to the loss of aircraft.	
152.	Trim	Ensure the AIP addresses the inspection and maintenance of the trim system. Many F-104s were lost because of malfunctions of this system. For example, a 2004 Italian Air Force F-104 accident illustrates this: "This day this aircraft, operated by 9 Stormo based at Grazzanise, encountered a pitch up problem on high level due to a damaged trim. The aircraft entered some +8 and -1 G maneuvers in order to recover which succeeded reaching already low altitude. Pilot Ten. Piercarlo 'Pierro' Ciacchi landed the aircraft safely but the aircraft was put into storage inside a maintenance hangar due to the possible high-G damages." Refer to http://www.i-f-s.nl/ACC00.html.	
153.	Landing Gear Retraction Test and Related Maintenance	Verify the AIP provides for the regular landing gear retraction test and related maintenance tasks, including documentation, per the applicable procedures and required equipment (that is, USAF or NATO).	
154.	Noise Wheel Steering	Verify that the AIP addresses the inspection and service of the nose wheel steering system. This is a critical system in the F0104 and many accidents have been caused by its malfunction.	
155.	Shimmy Damper Unit	Verify the AIP addresses inspection of the shimmy damper units. The F-104 had a persistent problem with severe nose wheel "shimmy" on landing, which usually resulted in the aircraft leaving the runway and in some cases even flipping over onto its back. Many crews were killed this way.	
156.	Honeycomb Structures	Verify the AIP provides for the inspection and replacement of all bonded honeycomb structures per the applicable guidance (that is, USAF or NATO).	
157.	Titanium Components	Verify the AIP incorporates detailed inspection of the aircraft's titanium components. The F-104 has some titanium components. Its heat resistance made it a particularly favored choice for the aft fuselage, adjacent to the engine. Although titanium is strongly corrosion resistant, electrical insulation between titanium and other metals is necessary to prevent galvanic corrosion of the other metal. Frequent inspection of such areas is required to ensure that insulation failure has not allowed corrosion to begin. Under certain conditions, chlorides and some chlorinated solvents may induce stress corrosion cracking of certain titanium alloys.	
158.	Flight Control Balancing, Deflection, and Rigging	Verify flight controls were balanced per the applicable maintenance manual(s) (that is, USAF or NATO) after material replacement, repairs, and painting. Verify proper rigging and deflection. In several former military aircraft, damage to flight controls has been noticed when inadequate repairs have been performed. If there are no adequate records of the balancing of the flight controls, the airworthiness certificate should not be issued.	
159.	Stick Shaker and Pusher System	Verify the AIP addresses inspection of the stick shaker and stick pusher system (sometimes called a "kicker system") per the applicable technical guidance. The high AOA area of flight was protected by a stick shaker system to warn the pilot of an approaching stall, and if this was ignored a stick pusher system would pitch the aircraft's nose down to a safer AOA; this was often overridden by the pilot despite flight manual warnings against this practice. Note: Operationally, some aircrews experienced un-commanded "stick kicker" activation at low level when flying straight and level, so some F-104 crews often flew with the system deactivated. See APC below.	
160.	APC	Verify the AIP addresses inspection of the APC or Automatic Pitch Control system. Many F-104s were lost because of an APC failure. In supersonic flight, the usual stall warnings were inadequate to prevent excessive AOA and an Automatic Pitch Control (APC) was provided which initiated corrective action at the proper time to prevent reaching an AOA high enough to cause pitch-up under any operating condition. These warnings took the form of a stick shaker and a kicker, which abruptly kick the stick forward. It is in effect, both a built-in buffet warning and an artificial stall that occurred ahead of the aerodynamic stall. Stall should never be practiced to completion; recovery action should be initiated at either shaker or kicker action, depending on configuration, and stalls should never be practiced below 25,000 feet AGL. See *Stick Shaker and Pusher System* above.	
161.	Speed Brakes	Verify proper condition, deflection, and warning signage of the speed brake per the applicable guidance (that is, USAF or NATO).	
162.	Yaw Damper	Verify any the yaw damper is addressed in the AIP per the applicable guidance (that is, USAF or NATO).	

Issue #	Issue(s)	Recommended Review, Action(s), and Coordination with Applicant	Notes, Action(s) Taken, and Disposition
163.	External Fuel Tanks	Verify drop tanks are cleared for use in the aircraft. The F-104 could carry a pair of tip tanks (170 US gal) (1,105 lb) and a pair of drop tanks on wing pylons 195 US gal (1,267 lb). Fletcher Aviation pylon tanks have no fuel quantity indicating system or low level float switch. Fletch pylon tanks are not compatible with the pressure refueling system and must be gravity fueled. External fuel tanks can be electrically jettisoned. See *170-Gallon Wing Tip Tanks* below.	
164.	170-Gallon Wing Tip Tanks	Verify the AIP and related servicing addresses the proper fitting, maintenance, and inspection of the 170-gallon wing tip fuel tanks. The F-104 could be fitted with two 170-gallon wingtip tanks. With these tanks, the maximum speed allowed was limited to Mach 1.08. The fuel weight and distribution in the tanks was critical, as an incorrectly loaded tip tank (with only the rearmost of its two compartments filled) could create aerodynamic flutter, building to a point where it would literally tear the wings off the aircraft.	
165.	Accurate Weight & Balance (W&B)	Review original W&B paperwork. Verify adherence to the applicable guidance (that is, USAF or NATO) as well as FAA-H-8083-1, Aircraft Weight and Balance Handbook, if documentation by the applicant appears to be inadequate. Several former military aircraft accidents have been linked to center of gravity miscalculations.	
166.	"Experimental" Markings	Verify the word "EXPERIMENTAL" is located immediately next to the canopy railing, on both sides, as required by § 45.23(b). Subdued markings are not acceptable.	
167.	N-Number	Verify the marking required by §§ 45.25 and 45.29(b) concerning the registration number (N-number), its location, and its size are complied with. If non-standard markings are proposed, verify compliance with Exemption 5019, as amended, under regulatory Docket No. 25731.	
168.	Type of Ejection Seat System	Identify the type of ejection seat fitted to the aircraft. The type of seat changes many aspects of operations and maintenance. In earlier F-104s, the Lockheed C-2 seat was installed, while many NATO countries, including Germany and Italy, installed Martin-Baker Mk. 7 ejection seats. The differences between the two types are significant. This changes many aspects of operations and maintenance. Note: The Germans used the Lockheed C-2 ejection seat up until early 1968 and then replaced all their aircraft seats with Martin Baker GQ-7A series seats. The Canadians (and Norway) kept the C-2 ejection seat throughout their tenure until 1983. All Danish Air Force aircraft were equipped with Martin Baker Mk. DQ-7 seats. All Greek and Italian aircraft were equipped with Martin Baker Mk GQ7A seats. The Japanese Air Force retained the Lockheed C-2 ejection seat used in the earlier USAF models. Italian F-104Gs were delivered with the Martin Baker 1Q7A ejection seat.	
169.	OEM Ejection Seat Support	Ask the applicant whether the ejection seat OEM still supports the ejection seat system, and whether it control part supplies. It is critical to clearly understand if and how the OEM supports both the earlier or upgraded ejections seat.	
170.	Ejection Seat System Maintenance	Ensure maintenance and inspection of the ejection seat and other survival equipment is performed in accordance with the applicable guidance (that is, USAF or NATO) by trained personnel. Include specific inspections and recordkeeping for pyrotechnic devices. Ejection seat system replacement times must be adhered to. No "on condition" maintenance may be permitted for rocket motors and propellants. Make the distinction between replacement times, that is, "shelf life" vs. "installed life limit." For example, a 9-year replacement requirement is not analogous to a 2-year installed limit. If such maintenance documentations and requirements are not available, the seat must be deactivated.	

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171.	Lockheed C-2 Auto Release System	If the Lockheed C-2 ejection seat is fitted, ensure the automatic release system that separates the pilot from the seat after ejection is properly inspected. Many F-104 accidents were fatal because, after ejection, the pilot was not able to separate himself from the seat. In 1959, at Wright-Patterson Air Force Base (AFB), an F-104 had such an incident. A narrative of the accident noted "an F-104 Starfighter from the 56th Fighter Squadron crashed near Valley pike. This crash caused an investigation to be launched, because the pilot, Lt. Col. Alston L. Brown (CO of the 56th FS), ejected from his disabled aircraft but did not survive. According to an article on the event, the automatic release that should have separated him from the seat did not engage, so he could not open his parachute. Brown's body was found still in the seat about a quarter of a mile from the crash site." The following account of an F-104G engine failure accident illustrates a case of a malfunctioning ejection seat: "It was 10:20 am on October 29, 1969, when instructor pilot Major Richard Doucette, and 2Lt. Manfred Peters, a West German student pilot, gently increased the throttle and lifted off in their F-104G Starfighter, call sign 'squirt,' from Luke AFB. Taking-off from runway 03R, they climbed to the proper altitude and took a heading for a place known as 'area 8,' about 15 miles SE of Ajo, Arizona used for training. Squirt arrived into 'area 8' cruising at 14,000 ft, where they performed aileron rolls, barrel rolls and VFR unusual altitudes training. Doucette coached Peters through these maneuvers and then decided to move north to another area for more training. Upon arriving in the area, Major Doucette had Lt. Peters initiate a dive to gain airspeed for a loop. He increased airspeed to 480 knots and selected afterburner and started the loop at 11,000 ft. As the aircraft was approaching 19,000 ft with airspeed of 200 knots, Major Doucette noticed there was a problem with the oil pressure and took control of the aircraft and initiated a roll-out and picked up a heading for Gila Bend AAF. As Lt. Peters observed the cockpit controls, his heartbeat quickened as he noticed that the NOQIS low-level light was on, engine oil pressure zero and the low-level oil light was on. Major Doucette then shut off the afterburner, set the power to 83% and maintained an airspeed of 220-230 knots while sending a distress call of 'Mayday, Mayday, Mayday' followed with his call sign, location and aircraft problem. As Doucette was instructing Peters to prepare for a bailout, they received acknowledgements from their distress call from Gila Bend and Davis-Monthan towers and were informed they were scrambling planes to their location. Following this transmission, heavy engine vibrations started and Doucette shut down the engine and told Peters they were to bailout now! He told Peters to pull the 'canopy jettison' handle and bail out 5 seconds after he did. Lt. Peters commented 'Good luck, see you on the ground,' then heard Major Doucette's ejection, waited, and then prepared for his own, noting the altitude was 15,000 ft. Holding the stick with one hand for level flight, he pulled the 'canopy jettison' and felt his ejection sequence start, then shoot him into the sky, followed by seat/man separation (in F-104 ejection seats, the pilot's ankles, waist and shoulders are strapped to the seat, and the straps and seat fall away from the pilot when a small 'release charge' is set off seconds after the ejection, that would release the straps and allow the pilot to fall free of the straps and seat, and then allow him to pull the ripcord), then the jerk of the parachute opening. As Lt. Peters floated down, he looked for Major Doucette's chute but couldn't see any sign of him. At this point, he knew something went terribly wrong as they had bailed out 3 miles high and he certainly should have seen the instructor's chute below him. The only thing Lt. Peters saw was the F-104 flying north in a slight dive and then disappear behind a ridge, followed by a loud explosion. As he landed, a pair of F-100's entered the area and located the F-104 crash and Lt. Peter's chute, but wondered where was Doucette's chute? As it happened, Major Doucette had ejected properly, but the seat had malfunctioned and the explosive charges had not gone off that would have allowed the straps to come undone. Instead, he was trapped to the seat for a fatal plunge. The accident investigation team and surgeon's medical report had proved that Major Doucette had fought the entire way down to try and free himself from the straps and had actually succeeded, but at an altitude too close to the ground and was unable to pull the ripcord in time." Refer to http://www.aircraftarchaeology.com/TF-104G%20Starfighter.htm.	
172.	Ejection Seat Components Life Limit	Ensure life-limit requirements concerning the ejection seat are followed. No deviations or extensions should be permitted. If the seat is not properly maintained, including current pyrotechnics, it must be disabled.	
173.	Crew Harnesses	Verify the harness used by the crew is the required type for the ejection seat used. Accidents have been fatal because of harness issues.	
174.	Ejection Seat System Maintainers Training	Require adequate ejection seat training for maintenance crews. On May 9, 2012, an improperly trained mechanic accidentally jettisoned the canopy of a former military aircraft while performing maintenance and was seriously injured.	
175.	Ejection Seat Modifications	Prohibit ejection seat modifications unless directly made by the manufacturer or permitted under the applicable and current technical guidance (that is, USAF, NATO).	
176.	Ground Support Equipment Maintenance	Verify the AIP provides for the proper maintenance of all required approved ground support equipment for the aircraft. Related technical guidance must be available as well.	
177.	Arresting Hook	Verify the AIP incorporates proper maintenance of the arresting hook per the applicable USAF TO. The maintenance of the hook is a critical safety issue with the F-104. Note: Of course, this hook was never intended for carrier-based operations, but was intended to engage arresting gear at the end of runways to prevent running off the runway during some emergency landing procedures.	
178.	Air Data Recorder (ADR) Box	If installed, recommend the ADR box be maintained. Toward the end of Luftwaffe service, some aircraft were modified to carry an ADR or "black box" that could give an indication of the probable cause of an accident.	

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F-104 Operating Limitations and Operational Issues			
179.	AIP and Related Documentation	Require adherence to the AIP and related documentation as part of the operating limitations.	
180.	Understanding of the Operating Limitations	Require the applicant to sign the Acknowledgment of Special Operating Limitations form.	
181.	Pilot in Command (PIC) Requirements	Ensure the operating limitations address PIC requirements. Direct transition from a modern corporate jet to a high-performance former military aircraft with minimum training is not a safe practice. Refer to the appropriate plot training and checking requirements in FAA Order 8900.1, volume 5, chapter 9, section 2. In addition to holding the required experimental authorization airplane category, the F-104 PIC should (1) have 20 hours dual training in the TF-104 in preparation for pilot authorization flight check, (2) have a structured ground school (similar to at least an USAF Short Course), (3) have 1,000 hours in high-performance fighter/fighter-bomber experience, including experience in second-generation aircraft such as the T-38, while F-16, F-18, and F-15 can be used for the total, (4) have proficiency and currency of 3 to 5 hours per month and five to six takeoffs and landings, and (5) follow standard USAF proficiency standardization check procedures (refer to *Checkout Procedures* below). Experience with only straight-wing jets such as the L-39 or T-33 is not sufficient. Pilots being sent on short “refresher” courses in slow and benign-handling first generation jet aircraft, and then sent to F-104 units, was a fatal flaw in many air forces, including the German Air Force. The same mistake should not occur in civil F-104 operations. The main reason the Spanish Air Force had a good operational record with the F-104 is that there was a requirement for 1,000 hours in high-performance jets before being assigned to an F-104 unit. Similarly, at one time, the Netherlands Air Force required 500 hours in an F-5 before transitioning to the F-104. In Turkish Air Force service, the F-104 was notoriously known as an unforgiving and difficult aircraft. The Turkish Air Force decided to post only seasoned pilots to the F-104 squadrons. To be eligible to fly the F-104, a pilot had to complete two combat readiness periods with frontline squadrons. Most pilots recruited to the F-104G had already logged 1,000 plus hours on other combat aircraft types. Consequently, the F104 squadrons were manned by crème de la crème of the Turkish Air Force in the early Starfighter days. See http://khas.academia.edu/SerhatGuvenc/Papers/1308401/Turkish_Starfighter_Training_1963-1995_Part_1_.	
182.	Recent Flight Experience	Recommend proficiency and currency of 3 hours per month and five to six takeoffs and landings. The typical general experience of “at least three takeoffs and three landings within the preceding 90 days” is not sufficient for the safe operation of the F-104.	
183.	PIC Currency in Number of Aircraft	Recommend the operator limit the number of tactical jets the F-104 PIC stays current on. The USAF restricted the number of aircraft types a pilot could hold currency on to two or three. This should be considered by operators who have several aircraft types in their inventory.	
184.	Flight Manuals	Ensure the PIC operates the aircraft as specified in the most current version of the flight manual (USAF manual, -1) for the F-104 version being flown. For example, if the aircraft are ex-Italian Air Force F-104Ss, the most current (as of 2006) flight manual will be required. On the other hand, if an ex-Royal Canadian Air Force (RCAF) CF-104D is involved, the most current RCAF guidance as of 1986 (when the RCAF retired the aircraft) may not include additional safety items addressed by the Turkish Air Force (NATO standard) for its remaining CF-104s between 1986 and 1995, when the aircraft was finally retired from that air force’s operational service. Note: The latest technical guidance may also be available from the USAF, which maintained much control over the aircraft COS, and upgrades though its operational service within NATO, as part of the Military Assistance Program.	
185.	Checkout Procedures	Recommend establishing an F-104 pilot checkout certification process similar to the USAF’s, as part of the experimental authorization. This training should include a structured ground school process and documentation covering the operation of the aircraft with an emphasis on emergency procedures. Except for weapons training, and some types of flight profiles and missions, there is no reason to deviate and especially permit minimally trained civil pilots to operate the F-104. On the other hand, experience has shown that, from an operator’s standpoint, one of the most important ways to mitigate the aircraft’s dangerous characteristic is intensive training, both initial and recurrent.	
186.	Annual Checkout	Recommend the PIC conduct an annual checkout on the aircraft.	
187.	F-104 PIC Differences Training	Recommend the applicant/operator provide for differences training between F-104 versions, and in some cases, variants. If a pilot has had recent experience in an F-104G, transitioning to the Italian F-104S ASA should include some training in the differences between these aircraft.	

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188.	Adequate Annual Program Letter	Verify the applicant's annual program letter contains sufficient detail and is consistent with applicable regulations and policies. (Many applicants/operators submit inadequate and vague program letters or fail to submit them on an annual basis.) Also verify the proposed activities (for example, an air show at a particular airport) are consistent with the applicable operating limitations (for example, avoiding populated areas) and do not pose a safety hazard, such as the runway being too short. There may be a need to review the proposed airports to be used.	

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189.	Additional Program Letter Guidance	Ensure program letters accompanying an application for an experimental airworthiness certificate meet the requirements of § 21.193. The letter must be detailed enough to permit the FAA to prescribe the conditions and limitations necessary to ensure safe operation of the aircraft. The letter must include— 1. The purpose for which the aircraft is to be used (such as R&D, crew training, or exhibition). 2. The purpose of the experiment. The letter must describe the purpose of the experiment and the aircraft configuration or modifications, and outline the program objectives. 3. The estimated number of flights or total flight hours required for the experiment and over what period of time (for example, days, or months). 4. The areas over which the experiment will be conducted. A written description or annotated map is acceptable. Specifically describe the area. Describing the operating area as "the 48 states," is not acceptable. The FAA may establish boundaries of the flight test area, including takeoff, departure, and landing approach routing to minimize hazards to persons, property, and other air traffic. However, it is the responsibility of the operator to ensure safe flight of the aircraft. 5. Unless converted from a type certificated aircraft, three-view drawings or three-view dimensioned photographs of the aircraft. 6. Any pertinent information found necessary by the FAA to safeguard the general public. The letter must also include any exemptions that may apply to the aircraft, such as non-standard markings or using an experimental aircraft for hire. 7. If using the aircraft for multiple purposes or roles, (1) documentation of all operations for each purpose, (2) a description of any configuration changes that will occur between each purpose to include adding or removing external stores and enabling or disabling systems, and (3) a separate section for each purpose. For example, an aircraft could have an experimental airworthiness certificate for the purposes of R&D and exhibition. The same aircraft may also conduct military, State, or PAO. In this example, the program letter must describe all three roles with the same level of detail. While the airworthiness certificate is not in effect, nor can the FAA prescribe limitations for PAO, the FAA cannot determine the appropriate certification for the aircraft without knowledge of how the aircraft is used. **SAMPLE— Research and Development / Exhibition - Applicant Program Letter for a Special Airworthiness Certificate** • Registered Owner (as shown on Certificate of Aircraft registration): N*AME: Brand X Support Services, Inc., ADDRESS: 123 Airport Street, Any Town, USA 00010.* • Aircraft Description: Registration Marks: i.e., *N12345,* Aircraft Yr. Mfg.: *1965,* Aircraft Serial No. 452*,* and Aircraft Model Designation: North American F-100. <u>R&D</u> • Describe program purpose for which the aircraft is to be used (14 CFR 21.193(d)(1)), i.e., *R&D providing chase for Major Airplane Manufacturer for certification testing of their next business jet. Aircraft Certification Office X is the project office. The assigned project number is ACOXzzz;* • Provide the following information as it pertains to your Program Letter (a) List estimated flight hours required for program, i.e. 75 hours, (b) List estimated number of flights required for program, number of flights, i.e. *50,* (d) List estimated duration for programs (14 CFR § 21.193(d)(2)), i.e. *150 days;* • Describe the areas over which the flights are to be conducted, and address of base operation (14 CFR 21.193(d)(3)), i.e., *the flights will take place within 150 nm of airport KAAA, excluding the airspace over City-X. The maximum altitude is FL240. The base of operations is Major Airplane Manufacturer Hangar, 12345 Tower Drive, City, etc.;* • Describe the aircraft configuration (attach three-view drawings or three-view dimensioned photographs of the aircraft (14 CFR 21.193(d) (4) and include a description of how the configuration is different from the other purposes listed). *See attached.* <u>Exhibition</u> • Describe program purpose for which the aircraft is to be used (14 CFR 21.193(d)(1)) such as e*xhibition at the following events over the next 8 months, i.e., AirVenture, August 1, 2013;* • Provide the following information as it pertains to your program letter (what you are planning to do for the next year or duration of certificate, whichever less): (a) estimated flight hours for the program broken down into operations (i.e. exhibition, training, flight to and from events); (b) estimated number of flights; • Describe the areas over which the flights are to be conducted, and address of base operation (14 CFR 21.193(d)(3)), i.e. c*rew training flights will take place within 125 nautical miles of Any Town, USA airport with a maximum altitude of 10,000 feet. The base of operations is the address listed above;* • Describe the aircraft configuration (attach three-view drawings or three-view dimensioned photographs of the aircraft (14 CFR 21.193(d)(4) and include a description of how the configuration is different from the other purposes listed). *See attached;* • Date, Name and Title (Print or Type), and Signature.	

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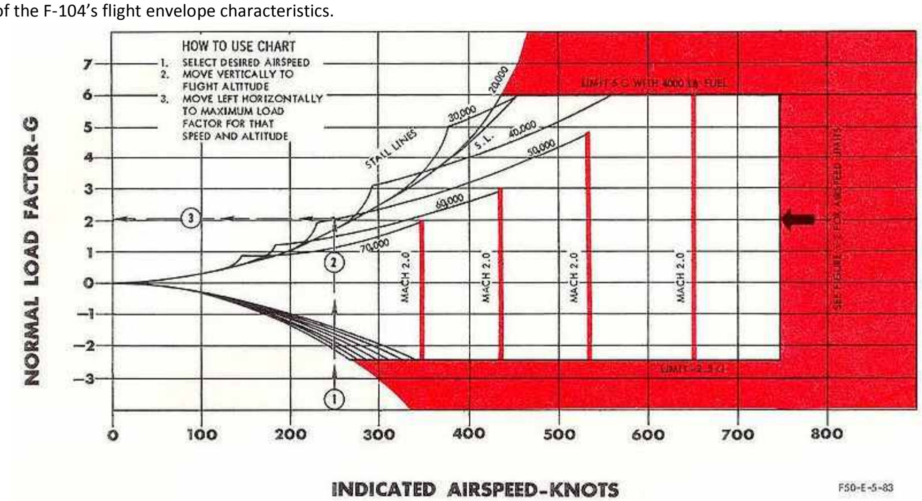
190.	Flight Manual Warnings, Cautions, and Notes	Consider requiring review (before flight) of all flight manual warnings, cautions, and notes. Such a review will greatly enhance safety, especially in those cases where the PIC does not maintain a high level of proficiency in the aircraft. The following definitions apply to warnings, cautions, and notes found throughout this instruction. Warning: Explanatory information about an operating procedure practice, or condition that may result in injury or death if not carefully observed or followed. Caution: Explanatory information about an operating procedure, practice, or condition that may result in damage to equipment if not carefully observed or followed. Note: Explanatory information about an operating procedure, practice, or condition that must be emphasized.	
191.	TO 1F-104-1 Section V Operating Limitations	Ensure the PIC operates the aircraft as specified in section V of TO 1F-104-1, Operating Limitations, in addition to the FAA-approved operating limitations.	
192.	USAF F-104 Safety Supplements	Verify the applicant/operator has incorporated the applicable F-104 safety supplements into operational guidance as appropriate. The most current version of the Airplane Flight Manual (AFM) (or "-1," the TO number for AFM) usually provides a listing of affected safety supplements, and this can be used as a reference. Safety Supplements addressed and updated safety issues. Refer to *USAF TO 0-1-1-5* below.	
193.	USAF TO 0-1-1-5	Verify the applicant/operator has incorporated the applicable and current TO 0-1-1-5 in the operational use of the aircraft. This TO provides a listing of all current flight manuals, safety supplements, operational supplements, and checklists. Also, check the flight manual title page, the title block of each safety and operational supplement, and the latest status pages contained in the flight manual or attached to formal safety and operational supplements.	
194.	Foreign Aircraft Particularities and Restrictions	Verify the aircraft includes aircraft-specific restrictions if it is of foreign origin. If those restrictions exist, the operator must understand those restrictions before flight, especially any post-restoration flight.	
195.	Operating Limitations	Ensure the PIC operates the aircraft as specified in the AFM section discussing Operating Limitations, in addition to the FAA-approved operating limitations. The VG graph below illustrates some of the F-104's flight envelope characteristics. 	
196.	Maintenance and Line Support	Verify the aircraft is operated with qualified crew chief/plane captains, especially during preflight and post-flight inspections as well as assisting the PIC during startup and shutdown procedures.	
197.	Ejection Seat System PIC Training	Require adequate ejection seat training for the PIC and crew, if applicable, for the type of seat installed. The PIC must also be able to ensure any additional occupant is fully trained on ejection procedures and alternate methods of escape. Evidence shows the safety record of attempted ejections in civilian former military aircraft is very poor, typically indicating inadequate training leading to ejections outside of the envelope. The ejection envelope is a set of defined physical parameters within which an ejection may be successfully executed.	

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198.	Ejection Seat System Ground Safety	Verify the safety of ejection seats on the ground. Verify ejection seats cannot be accidentally fired, including prohibiting untrained personnel from sitting on the seats. As NAVAIR states, "the public shall be denied access to the interior of all aircraft employing ejection seats or other installed pyrotechnic devices that could cause injury." In addition, operators should provide security during the exhibition of the aircraft to prevent inadvertent activation of the ejection system from inside or outside the aircraft by spectators or onlookers. The PIC on a recent jet warbird operation noted: "Recently we had a case where a guest in the back jettisoned the rear canopy on the ground at the parking position while trying to lock the canopy with the lever on the R/H side… The canopy went straight up for 6 m (20 ft) and fell back on the ground, right in front of the left wing leading edge next to the rear cockpit (fortunately not straight back on the cockpit to punish the guy)." Note: Any ejection seat training must include survival and post-bailout procedures, based either on U.S. Navy or USAF training (or NATO), as appropriate for the equipment being used. Note: As a result of accidents, DOD policy prohibits the public from sitting on armed ejection seats.	
199.	Ejection Seat System Safety Pins	Require the PIC to carry the aircraft's escape system safety pins on all flights and high-speed taxi tests. As a recommendation stemming from a fatal accident, the U.K. CAA may require "operators of civil registered aircraft fitted with live ejection seats to carry the aircraft's escape systems safety pins (a) on all flights and high-speed taxi tests (b) in a position where they are likely to be found and identified without assistance from the aircraft's flight or ground crews."	
200.	Stanley C-1 Ejection Seat	Prohibit the installation and use of the Stanley C-1 ejection seat. This was a downward-firing ejection seat fitted to early F-104s.	
201.	Parachutes	Comply with § 91.307, Parachutes and Parachuting. This regulation includes requirements that the parachute must (1) be of an approved type and packed by a certificated and appropriately rated parachute rigger, and (2) if of a military type, be identified by an NAF, AAF, or AN drawing number, an AAF order number, or any other military designation or specification number. The parachute must also be rated for the particular ejection seat being used.	
202.	J79 Engine Operating Limits	Adhere to all engine limitations in the applicable flight manuals.	
203.	Spool Down Time	Verify the AIP incorporates action(s) following a change in the spool down time of the J79 engine(s) after shutdown. This is critical as it could be an indicator of an upcoming problem with the J79 engine.	
204.	External Stores	Prohibit the installation of external stores that were not approved by the military service (that is, USAF or NATO). Under FAA Order 8130.2, only aircraft certificated for the purpose of R&D may be eligible to operate with functional jettisonable external fuel tanks or stores, but the safety of people and property on the ground still must be addressed. As the NTSB stated in 2012 following the fatal accident of a high-performance experimental aircraft, "the fine line between observing risk and being impacted by the consequences when something goes wrong was crossed." In many cases, the pilots may understand the risks they assumed, but the spectators' presumed safety has not been assessed and addressed. Refer to *External Fuel Tanks (General)* below.	
205.	External Fuel Tanks (General)	Verify the type, condition, installation, and removal of drop tanks meet requirements of the manufacturer or military operator. Only external tanks cleared for use by the USAF may be used on the aircraft. The aircraft records and the AIP must document the type of tanks that can be used on the aircraft, that is, the 170-gallon wing tip tanks. No homemade fuel tanks are permitted. The only modification allowed to the external tanks is to prevent jettisoning. Accidental jettisoning of the tanks is a safety hazard. Any means of releasing the tanks during aircraft operation must be disabled. In the F-104, this system is operated by the # 2 Battery Bus. There have been several cases of external fuel tank separations on the ground and in flight. Sometimes, the pilot jettisons the tanks, but the risk to those on the ground and property was not mitigated. This is not an imaginary risk. For example, on October 14, 1959, an USAF jet began having engine problems. "In an effort to make it back to Wright-Patterson AFB, the pilot tried to jettison the wing-tip fuel tanks to lighten the aircraft. One of the fuel tanks, weighing some 1400 pounds with fuel, happened to fall on the Lanning residence. The tank went through several walls and killed the family dog." Refer to http://www.libraries.wright.edu/special/ddn_archive/2012/12/11/wright-patterson-afb/.	
206.	Wing Tip Ejector Cartridges	Prohibit the installation of the wing-tip external fuel tanks ejector cartridges.	
207.	Emergency Stores Release Handle (ESRH)	Disable the ESRH, if applicable.	
208.	Master Armament Switch	Disable and disconnect the master armament switch from any system. Weapon-related buttons (bomb/rocket button, trigger) on the control stick grip and panels must also be disabled and disconnected from all systems.	
209.	Restrict Acrobatics	Restrict acrobatics per the appropriate flight manual.	

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210.	Mach Meter and Airspeed Calibration	Require the installation and calibration of a Mach meter or verify the PIC makes the proper Mach determination before flight. Unless the airspeed indicator is properly calibrated, transonic range operations may have to be restricted. See *V_{ne} of .9 Mach* below.	
211.	Accelerometer	Ensure the aircraft's accelerometer is functional if one is provided. This instrument is critical to remain within the required G limitation of the aircraft.	
212.	V_{ne} of .9 Mach	Restrict airspeed to .9 Mach. This provides a good safety margin and could be addressed in the operating limitations, the AFM, and related SOPs.	
213.	Phase I Flight Testing	Recommend, at a minimum, all flight tests and flight test protocol(s) follow the intent and scope of acceptable USAF/U.S. Navy functionality test procedures. The aircraft needs detailed Phase I flight testing for a minimum of 10 hours. Returning a high-performance aircraft to flight status after restoration cannot be accomplished by a few hours of "flying around." Safe operations also require a demonstrated level of reliability.	
214.	Post-Maintenance Check Flights	Recommend post-maintenance flight checks be incorporated in the maintenance and operation of the aircraft and TO 1-1-300, Maintenance Operational Checks and Flight Checks, dated June 15, 2012, be used as a reference.	
215.	Flight Over Populated Areas	Prohibit flights over populated areas, including takeoffs and landings, if an ejection seat is functional. If not, the aircraft may be operated over populated areas for the purpose of takeoff and landing only, and only in Phase II operations. The area on the surface described by the term "only for the purpose of takeoff and landing" is the traffic pattern. For the purpose of this limitation, the term "only for the purpose of takeoff and landing" does not allow multiple traffic patterns for operations such as training or maintenance checks. As the NTSB stated in 2012 following the fatal accident of a high-performance experimental aircraft, "the fine line between observing risk and being impacted by the consequences when something goes wrong was crossed." In many cases, the pilots may understand the risks they assumed, but the spectators' presumed safety has not been assessed and addressed. Note: Depending on the aircraft type or specific operational issues, additional limitations maybe considered regarding flights over populated areas.	
216.	Controlled Bailout Area	If operational procedures require the establishment of a controlled bailout area, ensure it (1) does not endanger people or property on the ground in any way, (2) follows established USAF/NAVAIR procedures, and (3) addresses the possibility of erratic flight paths after ejections. Refer to *Flight Over Populated Areas* above.	
217.	G Limitations	Ensure conservative G limits. Many of these aircraft have structural problems dictating this prudent approach. There is no justification to take the aircraft anywhere near its original limitations. The fact that the aircraft could be G loaded does not mean such performance should be attempted or is inherently safe. This is especially true given the aircraft's age and historical use. Maximum G limits should be established below design specifications based on the age and condition of the airframe. Particular attention to the condition of the wings is required because in-flight breakups with the original wings have occurred recently.	
218.	Visual Meteorological Condition (VMC)	Allow day VMC operations only.	
219.	Carrying of Passengers, § 91.319(a)(2)	Prohibit the carrying of passengers at all times. No rides. Legitimate flight training is permitted only in accordance with an FAA-issued letter of deviation authority (LODA).	
220.	Passenger Training and Limitations	Implement adequate training requirements and testing procedures if a person is carried on the back seat [refer to *Carrying of Passengers, § 91.319(a)(2)* above for limitations under § 91.319(a)(2)] to allow the performance of that crew's position responsibilities per the applicable Crew Duties section of the USAF Flight Manual. This training should not be a simple checkout, but rather a structured training program (for example, ground school on aircraft systems, emergency and abnormal procedures, "off-limits" equipment and switches, and actual cockpit training). The back seat qualification should also include (1) ground egress training (FAA-approved ejection seat training), (2) ejection seat and survival equipment training, (3) abnormal/emergency procedures, and (4) normal procedures. In addition to any aircraft-specific (that is, systems and related documentation) training, it is recommended that the *Naval Aviation Survival Training Program* (Non-aircrew NASTP Training) or/and *the United States Air Force Aerospace Physiology Program* (AFI 1 I-403, Aerospace Physiological Training Program) be used in developing these programs. In addition, passenger physiological and high-altitude training should be implemented for all operations above 18,000 ft. This issue can be addressed as part of the operating limitations by requiring the right seat training and incorporating the adequate reference (name) of the operator's training program.	

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221.	Stall and Spins	Prohibit intentional stall and spins. Due to the aerodynamics of the high "T" tail, the aircraft was prone to a phenomenon known as "Pitch-Up" at high AOA. Beyond a certain point, this pitch-up was uncontrollable and resulted in severe gyration (or even structural failure) of the aircraft and a large loss in altitude before recovery to level flight. It is possible to develop stall angles of attack very readily and rapidly during abrupt maneuvers, even though relatively small amounts of stabilizer are used. Note: Spins can be violent, gut-wrenching and should be prohibited. Although the ailerons are effective past the stall speed, and the aircraft can be recovered to a recognizable flight attitude with little input, the altitude loss in an out-of-control situation is enormous. If loss of control is not corrected by 15,000 feet AGL, the checklist procedure dictates EJECTION. One accident investigation after a CF-104 was lost (successful ejection) to an unrecoverable spin revealed that the with an absolutely clean aircraft configuration with only 1700 pounds of fuel and an empty cannon ammunition bin, resulted in an aft centre of gravity which made the spin irrecoverable. Spin entry would also have been near impossible without this aft C-of-G condition.	
222.	Air Refueling	Prohibit air refueling and ensure related equipment is to be disabled.	
223.	Asymmetric Wing Mounted Stores	Prohibit asymmetric wing mounted equipment regardless of the USAF/NATO AFM or -1.	
224.	Reduce Vertical Separation Minimums (RVSM)	Prohibit operations above RVSM altitudes (FL290).	
225.	High-Altitude Training	Recommend the PIC complete an FAA-approved physiological training course (for example, altitude chamber). Refer to FAA Civil Aerospace Medical Institute (CAMI) Physiology and Survival Training website for additional information.	
226.	Minimum Equipment for Flight	Ask the applicant to specify minimum equipment for flight per applicable USAF guidance, and develop such a list consistent with the applicable requirements (that is, USAF or NATO) and § 91.213. These documents list the minimum essential systems and subsystems that must work on an aircraft for a specified mission.	
227.	Post-flight and Last-Chance Check Procedures	Recommend the establishments of post-flight and last-chance inspection per the applicable guidance (that is, USAF or NATO). Note: Last-chance checks may include coordination with the airport and air traffic control (ATC) for activity in the movement areas.	
228.	Minimum Runway Length	Recommend a minimum runway length be established. In addition, ensure the PIC verifies, using the appropriate aircraft performance charts (Performance Supplement), sufficient runway length is available considering field elevation and atmospheric conditions. To add a margin of safety, use the following: <u>For Takeoff</u> • No person may initiate an airplane takeoff unless it is possible to stop the airplane safely on the runway, as shown by the accelerate-stop distance data, and to clear all obstacles by at least 50 ft vertically (as shown by the takeoff path data) or 200 ft horizontally within the airport boundaries and 300 ft horizontally beyond the boundaries, without banking before reaching a height of 50 ft (as shown by the takeoff path data) and after that without banking more than 15 degrees. • In applying this section, corrections must be made for any runway gradient. To allow for wind effect, takeoff data based on still air may be corrected by taking into account not more than 50 percent of any reported headwind component and not less than 150 percent of any reported tailwind component. <u>For Landing</u> • No person may initiate an airplane takeoff unless the airplane weight on arrival, allowing for normal consumption of fuel and oil in flight (in accordance with the landing distance in the AFM for the elevation of the destination airport and the wind conditions expected there at the time of landing), would allow a full stop landing at the intended destination airport within 60 percent of the effective length of each runway described below from a point 50 ft above the intersection of the obstruction clearance plane and the runway. For the purpose of determining the allowable landing weight at the destination airport, the following is assumed: o The airplane is landed on the most favorable runway and in the most favorable direction, in still air. o The airplane is landed on the most suitable runway considering the probable wind velocity and direction and the ground handling characteristics of that airplane, and considering other conditions such as landing aids and terrain.	
229.	Runway Considerations	Consider accelerate/stop distances, balanced field length, and critical field length in determining acceptable runway use per CJAA guidance. To enhance operations, it is recommended takeoff procedures similar to the USAF minimum acceleration check speed (using a ground reference during the takeoff run to check for a pre-calculated speed) be adopted.	

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230.	Barrier MA-1 and BAK-6 and BAK-9 Cable Arresting Systems	Recommend the use of a barrier (MA-1A) or arresting cable system (BAK) be considered where available. If a barrier or arresting cable system is used, ensure procedures be developed for this. Refer to AC 150/5220-9, Aircraft Arresting Systems on Civil Airports, dated December 20, 2006. The military installs and maintains aircraft arresting systems when certain military operations are authorized at civil airports. Aircraft arresting systems serve primarily to save lives by preventing aircraft from overrunning runways in cases where the pilot is unable to stop the aircraft during landing or aborted takeoff operations. They also serve to save aircraft and prevent major damage. Aircraft arresting systems must be installed according to the latest official criteria of the military aircraft operational need. In most cases, the criteria can be found in AF 32-1043, Managing, Operating, and Maintaining Aircraft Arresting Systems.	
231.	Runway Condition Reading (RCR) and Runway Surface Condition (RSC)	Consider using Runway Condition Reading (RCR) numbers in all F-104 operations. RCR is a measure of tire-to-runway friction coefficient. RCR is given as a whole number. This value is used to define the braking characteristics for various runway surface conditions. The reported RCR is therefore a factor in determining any performance involving braking, such as critical engine failure speed and refusal speed. Some airfields report runway braking characteristics in accordance with International Civil Aviation Organization (ICAO) documents, as good, medium, and poor. These can be related to ICAO categories. Similarly, Runway Surface Condition (RSC) can also be used. RSC is the average depth covering the runway surface measured to 1/10 inch (1 inch is equivalent to a RSC of 10). RSC types include: wet runway, standing water, slush on runway, and loose snow on runway. Refer to FAA Order JO7110.65, February 2012 and applicable military guidance.	
232.	Jet Exhaust Dangers	Establish adequate jet blast safety procedures per the appropriate guidance (that is, USAF or NATO).	
233.	Servicing and Flight Servicing Certificate	Ensure the applicant verifies ground personnel are trained for operations with an emphasis on the potential for fires during servicing. Prohibit non-trained personnel from servicing the aircraft. Recommend a Flight Servicing Certificate or similar document be used by the ground personnel to attest to the aircraft's condition (that is, critical components such as tires) before each flight to include the status of all servicing (that is, liquid levels, fuel levels, hydraulic fluid, and oxygen). Specific servicing areas may include: oxygen tanks and filler, fuel fillers, engine oil tank, brake control units, batteries, external power receptacles, rain removal system, single-point refueling (should be disabled), emergency air bottle and filler, and hydraulic reservoir.	
234.	Ground Support Equipment	Verify all required ground equipment for the F-104 is available and in a serviceable condition per the applicable USAF TOs.	
235.	Aerial Target Towing	Prohibit all aerial towing. Notwithstanding the standard language in the FAA Order 8130.2 limitations concerning towing, the F-104 is not to be used for towing targets because such operations pose a danger to property and people on the ground and endanger the aircraft. For example, there have been cases where the aerial target (that is, the K-11 tow target and cable, TDU-10 Dart Gunnery Target System, A/A 37U-15 tow subsystem) collided with the aircraft causing fatal damage to the flight controls system. The risk for midair collision is also too great. Moreover, some target towing systems' separation mechanism may include explosives, while others cannot be released, which poses hazards during landing.	
236.	Drag Chute Installation and Use	If a drag chute is installed, verify it is done per the applicable technical guidance (that is, USAF or NATO). However, this does not mean it can be used to reduce the needed landing distance. In other words, it cannot be used as part of any landing distance calculation. Note: In the F-104, the drag chute is an 18 foot diameter drag chute used to reduce landing distance and brake wear. It is stowed in the lower aft fuselage.	
237.	Hot and Pressure Refueling	If the aircraft is so equipped, prohibit hot and pressure refueling. There are too many dangers with these types of operations.	
238.	Personal Flight Equipment	Recommend the operator use the adequate personal flight equipment and attire to verify safe operations. This includes a helmet, oxygen mask, fire retardant (Nomex) flight suit, gloves (that is, Nomex or leather), adequate foot gear (that is, boots), and clothing that does not interfere with cockpit systems and flight controls. Operating with a live ejection seat requires a harness. Therefore, recommend only an approved harness compatible with the ejection seat be used.	

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239.	Aircraft Rescue and Fire Fighting (ARFF) Coordination	Coordinate with ARFF personnel at any airport of landing. A safety briefing should be provided and include: an ejection seat system overview; making the ejection seat safe, including location and use of safety pins; canopy jettison; fuel system, fuel tanks; intake dangers, engine shut-off throttle; fuel; batteries; flooding the engines; fire access panels and hot exhaust ports; and crew extraction-harness, oxygen, communications, and forcible entry. ARFF personnel should be provided with the relevant sections of the aircraft AFM and other appropriate references like Fire Fighting and Aircraft Crash Rescue, Vol. 3, Air University, Maxwell AFB, 1958. An additional reference is the NATOPS U.S. NAVY Aircraft Firefighting and Rescue Manual, NAVAIR 00-80R-14, dated October 15, 2003. The FAA maintains a series of ACs that provide guidance for Crash Fire Rescue personnel. Refer to AC 5210-17, Programs for Training of Aircraft Rescue and Firefighting. Note: On November 1, 2012, the NTSB issued Safety Recommendation A-12-64 through -67. The NTSB recommends the FAA require the identification of the presence and type of safety devices (such as ejection seats) that contain explosive components on the aircraft. It further stated that that information should be readily available to first responders and accident investigators by displaying it on the FAA's online aircraft registry and that the FAA should issue and distribute a publicly available safety bulletin to all 14 CFR part 139-certificated airports and to representative organizations of off-airport first responders, such as the International Association of Fire Chiefs and the National Fire Protection Association, to (1) inform first responders of the risks posed by the potential presence of all safety devices that contain explosive components (including ejection seats) on an aircraft during accident investigation and recovery, and (2) offer instructions about how to quickly obtain information from the FAA's online aircraft registry regarding the presence of these safety devices that contain explosive components on an aircraft.	
240.	Coordination With Airport	Ensure the applicant provides objective evidence that the airport manager of the airport where the aircraft is based has been notified regarding both the presence of explosive devices in these systems and the planned operation of an experimental aircraft from that airport.	
241.	ATC Coordination	Coordinate with ATC before any operation that may interfere with normal flow of traffic to ensure the requirement to avoid flight over populated areas is complied with. Note: ATC does not have the authority to waive any of the operating limitations or operating rules.	
242.	Formation Takeoffs and Landings	Prohibit formation takeoffs and landings. There is no civil use, including display, to justify the risks involved.	
243.	Military/Public Aircraft Operations	Require the operator to obtain a declaration of PAO from the contracting entity or risk civil penalty for operating the aircraft outside the limits of the FAA experimental certificate. Some operators may enter into contracts with the DOD to provide military missions such as air combat maneuvering, target towing, and ECM. Such operations constitute PAO, not civil operations under FAA jurisdiction. Verify the operator understands the differences between PAOs and operations under a civil certificate. For example, the purpose of an airworthiness certificate in the exhibition category is limited to activities listed in § 21.191(d). Note: The following notice, which was issued by AFS-1 in March 2012, should be communicated to the applicant: "Any pilot operating a U.S. civil aircraft with an experimental certificate while conducting operations such as air-to-air combat simulations, electronic counter measures, target towing for aerial gunnery, and/or dropping simulated ordinances is operating *contrary* to the limits of the experimental certificate. Any operator offering to use a U.S. civil aircraft with an experimental certificate to conduct operations such as air-to-air combat simulations, electronic counter measures, target towing for aerial gunnery, and/or dropping simulated ordinances pursuant to a contract or other agreement with a foreign government or other foreign entity would not be doing so in accordance with any authority granted by the FAA as the State of Registry or State of the Operator. These activities are not included in the list of experimental certificate approved operations and may be subject to enforcement action by FAA. For those experimental aircraft operating overseas *within* the limitations of their certificate, FAA Order 8130.2, section 7, paragraph 4071(b) states that if an experimental airworthiness certificate is issued to an aircraft located in or outside of the United States for time-limited operations in another country, the experimental airworthiness certificate must be accompanied by appropriate operating limitations that have been coordinated with the responsible CAA *before* issuance." For additional information on public aircraft status, refer to 76 FR 16349, Notice of Policy Regarding Civil Aircraft Operators Providing Contract Support to Government Entities (Public Aircraft Operations), dated March 23, 2011.	
244.	TO 00-80G-1 and Display Safety	Recommend using TO 00-80G-1, Make Safe Procedures for Public Static Display, dated November 30, 2002, in preparing for display of the aircraft. This document addresses public safety around aircraft in the air show/display environment. It covers hydraulics, egress systems, fuel, arresting hooks, electrical, emergency power, pneumatic, air or ground launched missiles, weapons release (including inert rounds), access panels, antennas, and other equipment that can create a hazard peculiar to certain aircraft.	

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F-104 Aircraft Flight Manual (AFM), SOPs, and Best Practices			
245.	Use of Operational Risk Management (ORM)	Recommend an ORM-like approach be implemented by the owner/operator. ORM employs a five-step process: (1) Identify hazards, (2) Assess hazards, (3) Make risk decisions, (4) Implement controls, and (5) Supervise. The use of ORM principles will go a long way in enhancing the safe operation of the aircraft. ORM is a systematic decision-making process used to identify and manage hazards. ORM is a tool used to make informed decisions by providing the best baseline of knowledge and experience available. Its purpose is to increase safety by anticipating hazards and reducing the potential for loss. The ORM process is utilized on three levels based upon time and assets available. These include: (1) Time-critical: A quick mental review of the five-step process when time does not allow for any more (that is, in-flight mission/situation changes); (2) Deliberate: Experience and brain storming are used to identify hazards and is best done in groups (that is, aircraft moves, fly on/off); and (3) In-depth: More substantial tools are used to thoroughly study the hazards and their associated risk in complex operations. The ORM process includes the following principles: accept no unnecessary risk, anticipate and manage risk by planning, and make risk decisions at the right level. As an example, as part of the safety improvement program, Lockheed test pilot Glenn 'Snake' Reaves visited all German F-104 operational units. By demonstrating limits and by giving detailed lectures about the performance characteristics of the Starfighter, he helped to increase the awareness among the squadron pilots of the performance limitations of the F-104. In other words, Reaves assisted on how to manage the risks of operating the aircraft.	
246.	System Safety MIL-STD-882B	Recommend the use of MIL-STD-882B, System Safety Program Requirements, in the operation of the aircraft. This guidance is also useful in the maintenance and operation of high-performance former military aircraft. It covers program management, risk identification, audits, and other safety-related practices.	
247.	Cockpit Resource Management (CRM) and Single-Pilot Resource Management (SRM)	Recommended the applicant and operator adopt a CRM-type program for aircraft operations. While CRM focuses on pilots operating in crew environments, many of the concepts apply to single-pilot operations. Many CRM principles have been successfully applied to single-pilot aircraft, and led to the development of SRM. SRM is defined as the art and science of managing all the resources (both on board the aircraft and from outside sources) available to a single pilot (prior and during flight) to ensure the successful outcome of the flight. SRM includes the concepts of Risk Management (RM), Task Management I, Automation Management (AM), Controlled Flight Into Terrain (CFIT) Awareness, and Situational Awareness (SA). SRM training helps the pilot maintain situational awareness by managing the automation and associated aircraft control and navigation tasks. This enables the pilot to accurately assess and manage risk and make accurate and timely decisions. Integrated CRM/SRM incorporates the use of specifically defined behavioral skills into aviation operations. Standardized training strategies are to be used in such areas as academics, simulators, and flight training. Practicing CRM/SRM principles will serve to prevent mishaps that result from poor crew coordination. At first glance, crew resource management for the single pilot might seem paradoxical but it is not. While multi-pilot operations have traditionally been the focus of CRM training, many elements are applicable to the single pilot operation. The Aircraft Owners and Pilots Association's (AOPA) Flight Training described single-pilot CRM as "found in the realm of aeronautical decision making, which is simply a systematic approach that pilots use to consistently find the best course(s) of action in response to a given set of circumstances." Wilkerson, Dave. September 2008. From a U.S. Navy standpoint, OPNAVINST 1542.7C, Crew Resource Management Program, dated October 12, 2001, can be used as guidance. Also refer to CRM For the Single Pilot. *Vector* (May/June 2008). FAA guidance includes: Summers, Michele M., Ayers, Frank Ayers, Connolly, Thomas Connolly, and Robertson, Charles. *Managing Risk through Scenario Based Training, Single Pilot Resource Management, and Learner Centered Grading*, 2007, and Chapter 17, *Airplane Flying Handbook* FAA-H-8083-3A. Note: Consider the use of AFI 11-290/AETC Sup 1, Cockpit/Crew Resource Management Training Program.	

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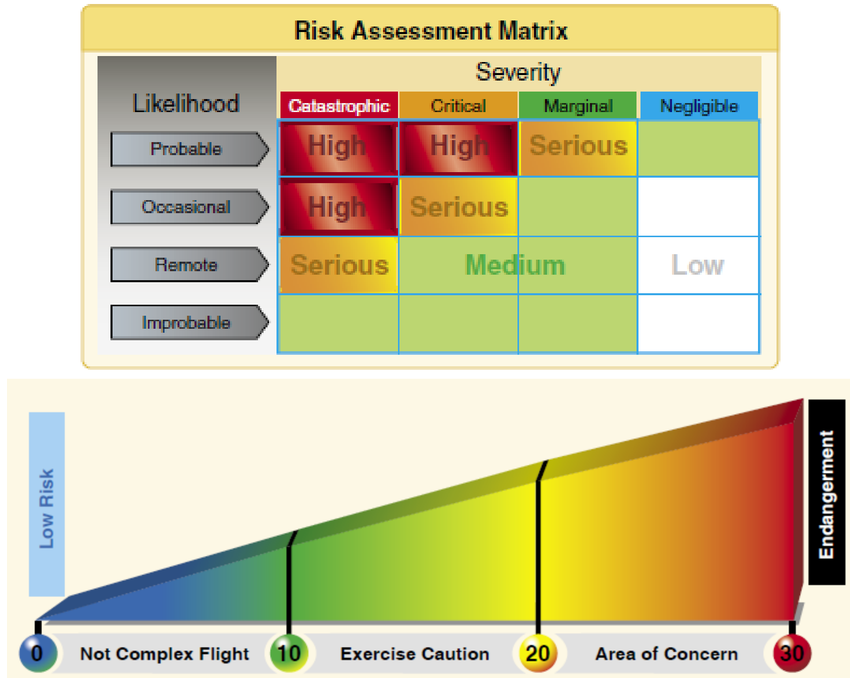
<tr><th>Issue #</th><th>Issue(s)</th><th>Recommended Review, Action(s), and Coordination with Applicant</th><th>Notes, Action(s) Taken, and Disposition</th></tr>
<tr><td>248.</td><td>Risk Matrix and Risk Assessment Tool</td><td>Recommend using a risk matrix in mitigating risk in aircraft operations. A risk matrix can be used for almost any operation by assigning likelihood and severity. In the case presented, the pilot assigned a likelihood of occasional and the severity as catastrophic. As one can see, this falls in the high risk area. The following is a risk assessment tool presented in figure 17-5 of the Airplane Flying Handbook, FAA-H-8083-3A.


Source: FAA</td><td></td></tr>
<tr><td>249.</td><td>AFM Addendums</td><td>Consider additions or restrictions to the AFM. Operational restrictions should be also addressed in the AFM.</td><td></td></tr>
<tr><td>250.</td><td>F-104 USAF (AFI) and F-104 Ground/Flight Training Guidance and Materials</td><td>Recommend the applicable USAF AFI, AFM, and manuals (or NATO equivalent) for the F-104 be used as an integral part of the operation of the aircraft. AFI, AFM, and guidance concerning F-104 includes aircrew training, evaluation criteria, flying fundamentals, and operations procedures for the F-104. In addition, recommend F-104 training incorporate USAF/NATO training films and multimedia. These materials, kept up-to-date in addressing many of the aircraft's shortcomings and angers, are critical for flight safety.</td><td></td></tr>
<tr><td>251.</td><td>USAF Phase Training</td><td>Recommend SOPs and training incorporate the current USAF Phases of Training. These include—
• Initial Qualification Training (IQT). This training is necessary to qualify aircrew for duties in the aircraft.
• Mission Qualification Training (MQT). This training is necessary to qualify aircrew for specific unit mission or local area requirements.
• Continuation Training (CT). This training is necessary for qualified aircrew to maintain their assigned level of proficiency and/or increase flight qualifications. It provides minimum ground and flight training event requirements.</td><td></td></tr>
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252.	In-Flight Canopy Separation	Revise the pilot checklist and back seat occupant briefing to emphasize (that is, "warning—caution") the proper closing of the canopy.	
253.	Fuel Mismanagement	Require special emphasis on fuel starvation and fuel management. Operator must be aware that it is important to note the total fuel load and compare to the fuel indicators to determine accuracy.	
254.	Speed Limitations Due To Avionics and Other Equipment	Verify the speed limit of the aircraft is adjusted to address installed avionics, which may have speed limitations.	
255.	Brake and Steering System	Recommend an adequate check-out on the aircraft's brake and steering system has been given to anyone taking control of the aircraft on the ground. Note: The following illustrates some details of the system: "The nosewheel is steerable 25 deg right or left of center. Steering is provided by a steer-damper unit that gets hydraulic pressure from the # 2 Hydraulic system as long as pressure remains above 2,175 psi. The hydraulic fluid is routed to the steering system through a solenoid shut-off valve, (engaged by the pilot via a button on the front of the stick), a filter, and a pressure reducing valve, lowering the pressure to 2,500 psi. Forces on the nosewheel are not transmitted back to the rudder pedals. Disengage nosewheel steering prior to rotation on takeoff to insure proper steering clutch release. On landing, engage nose steering after nosewheel is firmly on the ground. Do not engage nosewheel steering if # 2 Hydraulic system fails. Air may enter the system and a violent shimmy can result." http://www.airplanedriver.net/study/f104.htm.	
256.	Drag Chute	Recommend that SOPs and training focus on the use of the drag chute as per the applicable USAF or NATO guidance. For example, a shear link will break, releasing the chute, if deployment occurs above 200 Kts. In addition, it should not be deployed unless the nose wheel is on the ground, and the engine is at idle.	
257.	Command Ejection	Ensure SOPs address the command ejection issue, that is, who ejects first, per the appropriate guidance (that is, USAF or NATO), before the flight if the back seat of the TF-104 is occupied. This is a significant issue and difference between F-104s that may be equipped with the older C-2 ejections seat or the newer Martin-Baker Mk. 7 seat. Note: This is very important because not only does the ejection sequence needs to be understood beforehand, but the PIC also must be able to ensure any additional occupant is fully trained on ejection procedures and alternate methods of escape.	
258.	Weight Limits for the Ejection Seats	Ensure the weight of any occupant meets design requirements for every flight, if the ejection seat is active.	
259.	High AOA	Ensure SOPs emphasize the risk of high AOA operations. At extremely high AOA, the F-104 was known to "pitch-up" and enter a spin, which in most cases was impossible to recover from. Many aircraft were lost to this problem. For a vivid illustration of this, refer to the video footage of a 1983 Canadian CF-104 accident at http://www.youtube.com/watch?v=FJtTYzUIwBQ.	
260.	V_{LE} During Takeoff	Ensure SOPs and training emphasize the aircraft's susceptibility to exceed its maximum gear-down speed (V_{LE}) of 260 knots, especially during takeoff. Because of the aircraft's tremendous acceleration, there might be a tendency to level off shortly after breaking ground to accelerate (for example, at air shows to demonstrate the aircraft's performance), but this can be an issue of literally seconds if the gear is not retracted before reaching that critical speed. Note: V_{LE} is the maximum landing gear extended speed. This is the maximum speed at which it is safe to fly a retractable gear aircraft with the landing gear extended.	
261.	Pitch-Yaw Coupling	Ensure SOPs and training address the F-104's propensity to experience Dutch roll. Dutch roll is a type of aircraft motion, consisting of an out-of-phase combination of "tail wagging" and rocking from side to side. This yaw-roll coupling is one of the basic flight dynamic modes (others include phugoid, short period, and spiral divergence). The stabilator (horizontal tail surface) was mounted atop the fin to reduce inertia coupling. Because the vertical fin was only slightly shorter than the length of each wing and nearly as aerodynamically effective, it could act as a wing on rudder application. To offset this effect, the wings were canted downward, at a 10 degrees anhedral angle.	
262.	Stick Shaker and Pusher System	Ensure SOPs and training emphasize the stick shaker and stick pusher system (aka "kicker system"). Flying with the system deactivated is not recommended, and the applicable and latest guidance on the matter (from the Italian Air Force) should be considered. The high AOA area of flight was protected by a stick shaker system to warn the pilot of an approaching stall, and if this was ignored, a stick pusher system would pitch the aircraft's nose down to a safer AOA; this was often overridden by the pilot despite flight manual warnings against this practice. Note: Operationally, some aircrews experienced un-commanded "stick kicker" activation at low level when flying straight and level, so some F-104 crews often flew with the system deactivated.	

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263.	BLCS	Ensure SOPs and training emphasizes the BLCS and its use. For example, high engine power had to be maintained on the final approach to ensure adequate airflow for the BLCS consequently pilots were warned not to cut the throttle until the aircraft was actually on the ground. Note: The Boundary Layer Control System (BLCS) uses air bled from the last compressor stage of the engine to direct over the wing for landing. Nozzles direct high pressure high temperature air over the upper surface of the flap when the LAND position is use. It reduces landing speed. System operation is automatic. Used only with a 45 degree flap setting. To enhance maneuverability and reduce landing speed, the entire leading edge is a separate structure which can be electrically "drooped" to increase low speed or high-angle-of-attack lift. The entire trailing edge is hinged, the outer panels being the ailerons, the inner panels flaps. Note: "On 23 March, a German F-104 suffered a fatal accident, which resulted in lengthy technical inspections and flying restrictions being applied to the F-104. Two pilots were flying a visual base leg when the (BLCS) malfunctioned. The aircraft immediately started to roll rapidly, became uncontrollable and crashed short of the runway. No ejection attempt was made by either of the two pilots. The immediate technical measurements included detailed inspections of all Starfighter BLCS ducts. Until the completion of the technical investigation, all landing approaches had to be made with the flaps set to 'Take-off' instead of 'Land', which required an increase of 20 knots to the Starfighter's final approach speed. As a result of this accident the remaining 29 F-104Fs, which were the oldest Starfighters in German service, were retired from active service by the end of June." Kropf, 1994.	
264.	LOC on Landing and Stall on Touch-and-Go	Ensure SOPs and training focus on the proper techniques for landing. Landing accidents, and especially LOC, were common. The F-104 is a difficult aircraft to land. Normal approach is flown at 175-180 kts with a touchdown speeds were between 155 and 160 knots at around 16,500 total weight, with an increase of 5 knots for every 1,000 lbs over normal landing weight and increases for crosswinds, gusty conditions, and other conditions as well.	
265.	Take-Offs Particularities	Recommend that SOPs and training emphasize the F-104's take-off characteristics. For example, in cold weather, (below zero degrees) the F-104 can accelerate so fast on Take off, that a pilot may reach 400 knots by the end of a 12,000 foot long runway. This could pose a problem for getting the landing gear up and locked because of its limiting speed of 260 kts. Hesitation after nose wheel rotation could result in an over speed indication. In hot weather (100 ° ambient and 140° runway temp), and if the F-104 is heavy, (full tip tanks and full pylon tanks) the takeoff roll can be lengthy and precarious. Takeoff speed may increase significantly to over 230 kts which is approaches the tire fail speed of 239 kts.	
266.	APC Failure	Recommend that SOPs and training emphasize APC failures. Many F-104 accidents were caused by this failure. An F-104 pilot recounts: "In 1981, I was leading a surface attack mission involving high-speed, low angle pop-up deliveries on one of the manned ranges. On recovery from the second pass during a 5 degree, 500 knot simulated CBU delivery, the aircraft began an un-commanded, rapid nose low pitch oscillation. During the first two large oscillations, the APC system fired, forcing the nose of the aircraft even lower. More bad news, because the emergency disconnect paddle switch on the stick ad no effect. At that point I momentarily considered ejection, but immediately decided that I was out of the operating envelope of the seat. While physically overpowering four more kicks of the stick with on hand, I was able to reach back with the other and turn the guarded APC switch to "off" by feel. I finally recovered the jet at less than 50 feet and remember seeing a very large desert cactus filling the front windscreen on the pullout. Later investigation revealed that the whole nightmare had been caused by an insidious break in the wiring in the stabilizer trim actuator and the pitch servo disconnect. During "G" loading, the wires separated, and unloading reconnected the wires. This malfunction was also greatly amplified by the full-functioning APC system. It was only after I had turned the APC system off that the oscillations ceased. I firmly believe that it was only my intimate knowledge of the Starfighter, based on a great deal of accumulated experience that saved my life that day. I had long since come to the conclusion that, under certain emergency conditions,… the decision to eject would have to be near-reflex."	
267.	J79 Air Start Procedures	Ensure SOPs and training emphasizes the correct on air start procedures. Incorrect air start procedures have caused several accidents involving former military high-performance aircraft.	

Issue #	Issue(s)	Recommended Review, Action(s), and Coordination with Applicant	Notes, Action(s) Taken, and Disposition
268.	J79 T-2 Reset	Ensure SOPs and training emphasizes a condition known as "T-2 reset," a normal function that made large stator blade angle changes, caused several engine failures on takeoff. "T-2 Reset," a normal function that made large stator blade angle changes, caused several engine failures on takeoff. It was discovered that large and sudden temperature changes (from being parked in the sun prior to getting airborne) were falsely causing the engine stator blades to close and choke the compressor. Note: The following explains the T-2 cutback function: "Supersonic aircraft engines must deal with a large range of airflow and inlet temperature. The by-pass flaps that open when the gear is up, allow ample excess air to flow around the engine such that the engine may more or less ingest what air it needs. Temperature is another matter. As the intake air gets warmer, there is a drop in density for a given pressure. Fuel control units take at least 4 variables into account when determining how much fuel to give the engine. They are: Compressor inlet temperature or "T2, Compressor discharges pressure, or "P3," Engine RPM, and Power Lever Angle. How hot, how much pressure, how much RPM, and how much thrust does the pilot want. The fuel control uses these variables to decide how much fuel is provided. As the speed increases, the temperature increases, remember our old friend ram rise. As the air gets warmer, the density decreases. The engine then would not be getting as much air it thinks it' getting at the same pressure. The fuel control, from 92 to 104 deg C inlet temperature, compensates for this by increasing rpm from 100 % to 104% to make up for the loss in density. When the engine inlet temperature exceeds 105 deg C, something else changes. Don't freak out if the engine rpm remains at 100% when you retard the throttle to idle. The CIT only gets to 105 deg C for one reason, you are going fast as hell, remember, and that's our old friend ram rise showing up. When you are going that fast, there is a lot of air being stuffed into the intake. The rpm must be kept high in order to ingest the air, or it will do the same thing you would do if you drink a warm coke to fast, it will burp! It, however will burp somewhat louder than you. We all refer to airplanes as females. They are less attractive when they burp. This one is designed not to. Don't worry, as speed and CIT decrease, the rpm will again begin to respond to the throttle. This is all normal." http://www.airplanedriver.net/study/f104.htm.	
269.	Afterburner Blow Out	Ensure SOPs and training address the possibility of an afterburner blowout on takeoff or even non-ignition resulting in a major loss of thrust, which could be detected by the pilot; in this situation, the recommended action is to abandon the takeoff. Many F-104 accidents resulted from this malfunction. The first fatal accident in German service was caused by this. See *Variable Thrust Nozzle* below.	
270.	Variable Thrust Nozzle	Ensure SOPs and training address the un-commanded opening of the variable thrust nozzle (usually through loss of engine oil). This is important because although the engine would be running normally at high power, the opening of the nozzle results in a drastic loss of thrust.	
271.	Configuration Checks	Recommend SOPs and training focus on configuration checks per the applicable USAF TOs.	

Issue #	Issue(s)	Recommended Review, Action(s), and Coordination with Applicant	Notes, Action(s) Taken, and Disposition
272.	Asymmetric Flap Extension	Recommend SOPs and training emphasize the possibility of asymmetric flap extension. The following National Aeronautics and Space Administration (NASA) F-104 accident narrative illustrates this: "Thompson strapped himself into the JF-104A cockpit, taxied to the runway, took off to the northeast and climbed to cruising altitude. Visibility was clear all along his route. Upon returning to Edwards, Thompson configured the airplane so he could practice simulated X-15 landings on the clay surface of Rogers Dry Lake. During his first approach he cut throttle, extended speed brakes and began a steep, descending turn toward a runway marked on the lakebed's surface. Decelerating, he lowered the flaps and held 300 knots indicated airspeed as he dove toward the airstrip. The jet lost altitude at a rate of 18,000 feet per minute until he leveled off at 800 feet, lit the afterburner and climbed away. During his second approach, Thompson noticed the airplane was rolling to the left. He applied full right aileron and rudder but failed to stop the motion. Seeing his airspeed dropping rapidly, he advanced the throttle to full and relit the afterburner. As his speed increased to 300 knots the roll ceased, leaving the airplane in a 90-degree left bank. Thompson increased his speed to 350 knots to gain more control effectiveness and began to troubleshoot the problem. JF-104A #56-0749 on the ramp at NASA's Flight Research Center on Edwards Air Force Base in 1959 with the Air Launched Sounding Rocket (ALSOR) attached to its underbelly. NASA test pilot Milton O. Thompson ejected from this aircraft on Dec. 20, 1962, after an asymmetrical flap condition made the jet uncontrollable. (NASA photo) Guessing that the airplane was experiencing an asymmetric control condition - either flaps or speed brakes - he repeatedly cycled the roll and yaw dampers, flap-selector switch and speed brakes. He verified that both flaps indicated 'up' and visually examined the exterior of the aircraft using his rear-view mirrors. The leading-edge flaps appeared to be up and locked but he couldn't see the trailing-edge flaps. Thompson knew he was in serious trouble and wasn't sure he could land safely. It slowly dawned on him that he might have to eject. In a last-ditch effort, Thompson radioed NASA-1 - the Flight Operations office - and urgently asked for fellow research pilot Joe Walker, who was suiting up for his X-15 mission. 'Trouble?' Walker asked. 'Right, Joe,' said Thompson, 'I'm running out of right aileron.' After a brief discussion, Walker decided one of the flaps might be locked in the down position and suggested that Thompson cycle the flap lever again. Thompson tried this and immediately knew it was a mistake, as the airplane started to roll rapidly. He soon realized the situation was hopeless. 'She's going, Joe!' he called. After four complete rolls, Thompson ejected while inverted. He felt a terrible pain in his neck as the seat's rocket motor blasted him free of the airplane. His body was whipped by air blast, and he began to tumble wildly. After rocket burnout, he separated from the seat but soon realized he was still holding onto the ejection handle. His parachute opened promptly as soon as he released his grip. Floating gently down from 18,000 feet, Thompson saw the airplane plummet nose-first into the desert and explode on the Edwards bombing range. He was breathing rapidly and felt lightheaded and slightly breathless. After several failed attempts to activate his bailout oxygen bottle, he unfastened his mask and breathed the thin, but fresh, air. He landed softly, gathered up his parachute, and walked to a nearby road. At NASA-1, the mood was grim. Thompson hadn't had time to inform anyone that he was ejecting and nobody saw his parachute. Their faces bearing shock and tears, NASA employees stared at the column of thick, black smoke rising in the distance. NASA Flight Operations chief Joe Vensel hopped in a car and sped across the lakebed toward the crash site, expecting the worst. To his surprise, he found Thompson waiting calmly by the roadside, apparently unharmed. An investigation revealed that the accident had most likely been the result of an electrical malfunction in the left trailing-edge flap. The investigating board, headed by Donald R. Bellman, gave Thompson high marks for his actions. 'Throughout the emergency,' the board's report read, 'the pilot showed superior skill and judgment, which contributed materially to his own safety and to the understanding of the causes of the aircraft loss.'" Refer to http://www.nasa.gov/centers/dryden/history/Features/Thompsons_Wild_Ride.html.	
273.	Asymmetric Slat Deployment	Recommend SOPs and training emphasize the possibility of asymmetyric slat deployment. Asymmetric flap deployment was another common cause of accidents.	
274.	Brake Application	Recommend SOPs and training focus on the proper application of braking action during landing, especially in unusual circumstances.	
275.	Oxygen Check	Recommend SOPs and training require the pilot to perform the "PRICE" (Pressure, Regulator, Indicator, Connections, and Emergency) check on the oxygen equipment before every flight if a pressure oxygen system is installed. The acronym "PRICE" is a checklist memory-jogger that helps pilots and crewmembers inspect oxygen equipment. Mix and match components with caution. When interchanging oxygen systems components, ensure compatibility of the components storage containers, regulators, and masks. This is a particularly important issue because the age of the aircraft may require the use of modern equipment, at least for some components.	
276.	Spool Down Time	Ensure SOPs incorporate noting the spool down time of the J79 engine after shutdown to complement the related maintenance action discussed above (in the green "Operations" section of this document).	
277.	End of Runway (EOR) Check	Recommend SOPs and training emphasize the importance of an EOR check.	
278.	Specific Range	Recommend SOPs address minimum landing fuel. Verify actual aircraft-specific range (nautical air miles traveled per pound of fuel used).	

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279.	Bingo and Minimum Landing Fuel	Recommend establishing SOPs addressing minimum landing fuel for IFR operations as provided in § 91.151, Fuel Requirements for Flight in VFR Conditions, in addition to § 91.167, to add a level of safety. In addition, a "Bingo" fuel status (a re-briefed amount of fuel for an aircraft that would allow a safe return to the base of intended landing) should be used in all flights. Note: Bingo fuel and minimum landing fuel are not necessarily the same, in that a call for Bingo fuel and a return to base still require managing the minimum landing fuel. See *Flight Time Block and Cross-Country Operations* below.	
280.	Flight Time Block and Cross-Country Operations	Because of the aircraft's notorious short range, recommend that in addition to Bingo and minimum landing fuel (see above), operators consider using a very conservative flight time block (i.e., maximum of 45 minutes) to ensure an additional level of safety to mitigate against any low-fuel situation, especially in cross-country operations.	
281.	Wet Runway	Recommend the applicant/operator refrain from operating the aircraft on any runway that has standing water.	
282.	Suspected Flight Control or Other Failures	Recommend establishing SOPs for troubleshooting suspected in-flight control or other failures, that is, specific checklist procedures, altitude, and clear location. This is very important due to the aircraft's history of flight control problems. The following description of an August 2000 F-104 accident illustrates this point: "At about 11:15 local time that day this Starfighter of 20°Gr (4°Wing) based at Grosseto performed a controlled crash into the sea, along the coast along Marina di Alberese, near Grosseto. The two pilots ejected safely. At the time of the crash there was one AB212 helicopter of the local 604°Sq. (SAR duty) was nearby. After a touch and go on Grosseto Air Base the landing gear was found seriously damaged (maybe due to a malfunction or due to a too hard landing). It was impossible to make a secure landing and it was decided to eject from the aircraft over sea after running out of fuel. One of the pilots was recovered by a private ship and returned via a boat of the civil fireman command of Grosseto. The other was recovered directly by the AB212 helicopter." Refer to http://www.i-f-s.nl/ACC00.html.	
283.	Rejected Takeoff	Recommend SOPs and training address the abort decision. Many F-104 accidents occurred because of poor planning and execution concerning an aborted take-off. In fact, the first fatal German Air Force accident happened on January 25, 1962: "A failure of the afterburner on takeoff had caused a severe loss of thrust, and the aircraft could not gain altitude and crashed into a storage hangar just beyond the airfield boundary. The pilot in the front cockpit ejected just prior to impact and landed without injury in a field. The instructor pilot in the back seat did not eject and was killed. The accident investigation revealed that a take-off abort after the afterburner failure would have prevented the accident." Kropf, 1994.	
284.	Over Rotation	Ensure SOPs and training emphasizes the concern of over rotation.	
285.	Pilot-Induced Oscillation (PIO)	Ensure SOPs and training emphasizes susceptibility to PIO on landing and takeoff. This phenomenon must be clearly understood by the PIC. Proper rotation and landing/flare technique is critical. Note: PIO, as defined by MIL-HDBK-1797A, is "sustained or uncontrollable oscillations resulting from efforts of the pilot to control the aircraft" and occurs when the pilot of an aircraft inadvertently commands an often increasing series of corrections in opposite directions, each an attempt to cover the aircraft's reaction to the previous input with an overcorrection in the opposite direction. An aircraft in such a condition can appear to be "porpoising," switching between upward and downward directions. As such it is a coupling of the frequency of the pilot's inputs and the aircraft's own frequency.	
286.	FAA AC 91-79	Recommend using AC 91-79, Runway Overrun Prevention. According to AC 91-79, safe landings begin long before touchdown. Adhering to SOPs and best practices for stabilized approaches will always be the first line of defense in preventing a runway overrun.	
287.	FAA AC 61-107	Recommend using AC 61-107, Operations of Aircraft at Altitudes Above 25,000 ft MSL and/or Mach Numbers (MMO) Greater Than 0.75. This AC can be used to assist pilots who are transitioning from aircraft with less performance capability to complex, high-performance aircraft that are capable of operating at high altitudes and high airspeeds. It also provides knowledge about the special physiological and aerodynamic considerations involved in these kinds of operations.	
288.	360-Degree Overhead Pattern Technique	Recommend the operator consider implementing SOPs to refrain from 360-degree overhead patterns. There is no civil application of this technique.	
289.	Low Approaches, High Speed, Low-Altitude Passes	Recommend no impromptu "low approaches" be permitted in normal operations outside approved air show routines and during the exhibition of the aircraft in that context. An exhibition airworthiness certificate is for exhibition purposes only. In many cases, operators engage in "spur-of-the-moment home air shows." Conducting such operations with an aircraft like the F-104 is not only inconsistent with the operating limitations typically issued, but is also a potentially dangerous activity because of (1) the lack of planning and coordination these operations entail, and (2) the inherent dangers of maneuvering this aircraft at low level. Unfortunately the F-104 was not as maneuverable as many other types of aircraft. At low level, this lack of maneuverability could be dangerous if a pilot was not paying close attention. Note: In a 2011 decision, the NTSB found that "high-speed, low-altitude operations were intentional fly-bys, rather than go-arounds."	

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290.	Crosswinds	Recommend the operator consider implementing SOPs that refer to conservative crosswind limitations (more conservative than those in the AFM) and adhere to the appropriate crosswind landing techniques.	
291.	Barrier MA-1 and BAK-6 and BAK-9 Cable Arresting Systems	Recommend the applicant/operator become familiar with these systems and coordinate (ahead of time) with the appropriate military entities (that is, USAF, Air National Guard, or U.S. Navy) that own these systems if any of these systems are located at any airport where operations are to take place or considered as an alternate airport given. In addition, the PIC is responsible for determining whether a barrier or arresting system is to be used, doing so per the applicable USAF guidance, and being aware of the dangers involved. Refer to http://www.youtube.com/watch?v=ZQ0rPecIPTM.	
292.	Outdoors	Recommend establishing SOPs to address the aircraft's sensitivities to weather, including hydraulic seal failures and leakages, freezing moisture, transparencies, air intake, and exhaust protection if necessary.	
293.	Reporting Malfunctions and Defects	Ask the applicant/operator to report (to the FSDO or MIDO) incidents, malfunctions, and equipment defects found in maintenance, preflight, flight, and post-flight inspection. This would yield significant safety benefits to operators and the FAA. A 2011 study for the U.S. Navy points to the effectiveness of such practices. It stated: "The data analysis carried out was a comprehensive attempt to examine the strength of the link between safety climate and mishap probability. Our findings would seem to support the premise that safety climate and safety performance are, at best, weakly related. Mishaps are rare events, and they describe only part of the spectrum of risks pertaining to a work system. We suggest that measuring workers' self-reported safety attitudes and behavior is an alternative way to assess the discriminate validity of safety climate." O'Connor, October 2011. In other words, reporting safety issues, such as malfunctions, goes a long way in preventing an accident.	
294.	Cockpit Familiarization	Recommend detailed and comprehensive F-104 SOPs/training (not unlike the military-style training known as "blindfold cockpit check with boldface items" conducted in a cockpit or cockpit simulator) be instituted to ensure adequate cockpit familiarization for the PIC.	
295.	Simulated Emergencies	Permit simulated emergencies only in accordance with the applicable F-104 flight manual (AFM or USAF -1), including emergency and abnormal checklists and in accordance with the limitations issued by the FAA for the aircraft. Some simulated emergencies in military use would not be permitted, including a simulated engine flame approach to an actual airport runway. See *Engine-Out Landing Practice* below.	
296.	Engine-Out Landing Practice (High Key/ Low Key)	Recommend the establishment of hard deck (i.e., 5,000 feet or higher) for any simulated engine-out landing practice. An USAF F-104 pilot explains: "The F-104 was sort of like owning the sharpest knife in the world….like using a sharp knife; you better not make any mistakes. It did not suffer fools at all. The engine-out landing pattern was wild; 15,000 and 260 over the runway and one turn, 240 knots over the threshold. Drop the gear by the emergency release during the flare! Rate of descent stabilized with gear down, engine off, at 240 knots was about 11,000 feet per minute. No slack there. The bird got a bad rep during its infancy - in the USAF about a third of them were lost to engine failure before GE got the bugs out of it. In the Luftwaffe a lot of accidents were due to a combination of green pilots, poor maintenance, and lousy (normal) European weather. With 4 tanks - fairly common configuration - the liftoff speed is around 215 knots. On an 8,000 foot runway there is NO slack at all." http://forum.keypublishing.com/showthread.php?t=20750. The narrative of the following 1957 F-104 accident illustrates the dangers of such maneuvers: "…the Lockheed pilot landed too hard, the right main gear collapsed and the aircraft skidded, then the left gear collapsed and the aircraft went of the runway, breaking the front fuselage. Gladly the aircraft did not caught fire and Jack Simpson could step out. It was after a test mission in which simulated flame-outs had been tested. During his fifth simulated flame-out landing he climbed to 20,000 ft. (above the terrain,) and circled to make a simulated flame-out approach to runway 22 at Palmdale. After permission of the tower he started a left 45 deg. bank. Everything went according to plan as he hit low key at 7,500 ft. at 240 knots, 276 mph. But when he started his final turn he was wide to the right of the runway. He quickly asked the tower for wind velocity and direction. "180 degrees at 20 knots, gusting to 28," the tower answered. Since he was blown of his flight path he added power to pull it in a little tighter to have his roll out on final at 1,000 ft. at about the 3/4 mile juncture at 240 kts. The pilot then made, what could have been a fatal mistake. He had to turn a little right to line up with the runway about the time he started his flare and he put the gear handle down. He was immediately dropping faster than expected and saw the end of the runway coming nearby quickly. He seemed to fill the cockpit. He pulled the 104 back to flare but it had no effect on his rate of closure. It was too late to avoid a rough touch down on the concrete. He stop cocked the throttle, and was in the process of unlocking the canopy when the aircraft hit the runway. One gear hit it after the other. The 104 bounced high, still launching forward, with great speed and force. The pilot pulled the drag chute lever but this had no effect. Then he pushed on the canopy to see if it was free to open. At last the aircraft which carried nickname 'Appleknocker' ended up along the runway with substantial and structural damage. It could not be repaired any more and was scrapped. Beneath two photos showing Lt. Simpson with his 55-2955 "Appleknocker" and a photo taken after the accident showing clearly the substantial damage to the airframe." http://www.i-f-s.nl/ACC50.html.	
297.	High-G Training	Recommend the PIC and any occupants received training, including techniques to mitigate the potential effects of high-G exposure if operations above 3 Gs are contemplated.	

Issue #	Issue(s)	Recommended Review, Action(s), and Coordination with Applicant	Notes, Action(s) Taken, and Disposition
298.	Medical Fitness for Ejection Seats	Recommend the applicant/operator consider aircrew medical fitness as part of flight qualifications and preparation. In addition to meeting any ejection seat limitations (that is, weight and height) and seat-specific training, relevant U.S. military medical fitness standards could be used to ensure survival after ejection is maximized and injuries minimized. Ejection records show that when survivable, many ejections inflict serious injuries. Examples of aeromedical guidance include AFI 48-123, Medical Examinations and Standards, dated May 22, 2001, and Army Regulation 40-501, Standards of Medical Fitness, dated June 14, 1989. Also refer to Defense and Civil Institute of Environmental Medicine, Department of National Defense, Canada. *Ejection Systems and the Human Factors: A Guide for Flight Surgeons and Aeromedical Trainers*, May 1988.	
299.	49 CFR Part 830	Ask the applicant/operator to adopt open and transparent SOPs that promote the use and requirements of 49 CFR Part 830, Notification And Reporting Of Aircraft Accidents or Incidents and Preservation of Aircraft Wreckage, Mail, Cargo, and Records, because there have been many instances where accidents and incidents are not reported, hindering safety. Occurrences, which are events other than an accident or incident (that requires investigation by the Flight Standards Service for its potential impact on safety), should also be reported. Occurrences include the following when no injury, damage, or § 830.5 reporting requirements are involved: (1) aborted takeoffs not involving a runway excursion, (2) air turn-backs where the aircraft returns to the departure airport and lands without incident, and (3) air diversions where the aircraft diverts to a different destination for reasons other than weather conditions. Reference should be made of FAA Order 8020.11, Aircraft Accident and Incident Notification, Investigation, and Reporting.	
300.	NATO Aviation Safety Guidance	Recommend the relevant sections of *Aviation Safety* AFSP-1(A), NATO, March 2007, be incorporated into the appropriate operational aspects of the operations to enhance overall safety. This document, which incorporates many safety issues concerning the safe operation of combat aircraft, sets out aviation safety principles, policies, and procedures—in particular those aimed at accident prevention. This document is a basic reference for everybody involved in aviation safety, both in occurrence prevention (starting from the development, testing, and introduction of material and procedures) and in its aftermath *(*the determination of the causes of an occurrence and the implementation of measures to prevent its recurrence). It is also recommended this process include internal safety audits. Safety audits help identify hazards and measure compliance with safety rules and standards. They assist in determining the adequate condition of work areas, adherence to safe work practices, and overall compliance with safety-based and risk-reduction procedures.	
301.	Aircrew Records	Recommend the applicant/operator establish and maintain processes to address aircrew qualifications and records. This could include pilot certification, competency, ground and flight training (records, instructors, conversion training, command training, and proficiency), medical, duty time, and flight time records.	
302.	Type Clubs or Organizations	Recommend the applicant/operator join a type club or organization. There are several such organizations dedicated to the F-104. This facilitates safety information collection and dissemination. They also provide an immense source of data, including accident data.	
303.	Emergency Planning and Preparedness	Recommend the applicant/operator institute emergency plans and post-accident management SOPs that ensure the consequences of major incidents and accidents to aircraft are dealt with promptly and effectively.	

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Attachment 4—Additional Resources and References

Additional Resources

- F-104 Accident data/reports (USAF, Italian AF, Luftwaffe, RNAF, Spanish AF, and other NATO countries).
- USAF F-104 Aircraft Accident Summary Reports, 1959-1975.
- Air Force Recurring Publication 91-1, *USAF Flying Safety* magazine.
- USAF Air Force Instructions (AFI) for the F-104.
- Australia's CAAP 30-3(0), *Approved Maintenance Organization (AMO) — Limited Category Aircraft*, Civil Aviation Advisory Publication, December 2001. This publication addresses the restoration and maintenance of ex-military aircraft and is an excellent guide for developing adequate aircraft maintenance and inspection programs.
- CAP 632, *Operation of Permit to Fly Ex-Military Aircraft on the UK Register*. This is a comprehensive source of information and guidance on topics like technical requirements, specialist equipment and systems, pilot/crew qualification, operational requirements, records and oversight procedure, and safety management.
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- USAF TO 1-1-300, *Maintenance Operational Checks and Flight Checks*, June 15, 2012.
- USAF TO 1-1-691, *Corrosion Prevention, and Control Manual.*
- USAF TO 1-1A-1, *Engineering Handbook Series for Aircraft Repair, General Manual for Structural Repair*, November 15, 2006.

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Attachment 5—Partial Listing of F-104 Accidents and Relevant Incidents

German F-104 Starfighter Losses (Luftwaffe and Marine Flieger) 1961-1989

A total of 298 German F-104 Starfighter were lost in accidents, losses on the ground and damaged beyond repair (including MAP F-104G serial number 62-12312) with the tragic death of 116 pilots, but 171 pilots ejected safely, 8 pilots ejected twice. Source: http://www.916-starfighter.de/GAF_crashes.htm.

Table Abbreviations	
AB	Afterburner
ACM	Air Combat Maneuvering
APC	Automatic Pitch Control
BFM	Basic Fighter Maneuvers
BLC	Boundary Layer Control
CFIT	Controlled Flight Into Terrain
FOD	Foreign Object Damage
GCA	Ground Controlled Approach
i/a	Instructional Aircraft

Date	Code	Const. Nr	Type	Unit	Remarks
29.03.1961	BB+375	5062	F-104F	WaSLw 10	engine failure due to malfunction of the fuel control unit near Korbach, both pilots ejected safely
06.09.1961	BB+378	5065	F-104F	WaSLw 10	flame out after fuel shortage due to loss of all navigation instruments near Gundelheim, both pilots ejected safely
25.01.1962	BB+366	5053	F-104F	WaSLw 10	afterburner blow-out during formation take-off at Norvenich AB, 1 pilot was killed, 1 pilot ejected safely
22.05.1962	DA+107	2029	F-104G	JaboG 31	engine failure after low fuel pressure near Jülich, pilot ejected to safety
19.06.1962	BB+365	5052	F-104F	WaSLw 10	ground contact near Knapsack of a 4 ship formation flight after disorientation of the leader, pilot was killed
19.06.1962	BB+370	5057	F-104F	WaSLw 10	ground contact near Knapsack of a 4 ship formation flight after disorientation of the leader, pilot (USAF) was killed
19.06.1962	BB+385	5072	F-104F	WaSLw 10	ground contact near Knapsack of a 4 ship formation flight after disorientation of the leader, pilot was killed
19.06.1962	BB+387	5074	F-104F	WaSLw 10	ground contact near Knapsack of a 4 ship formation flight after disorientation of the leader, pilot was killed
03.09.1962	DA+116	2019	F-104G	JaboG 31	loss of aircraft control after take-off from Norvenich due to too early gear retraction, pilot ejected too late and was fatally injured
31.01.1964	VA+111	7091	F-104G	MFG 1	midair collision in high altitude formation near Leck AB, pilot ejected to safety
31.01.1964	VA+112	7092	F-104G	MFG 1	midair collision in high altitude formation near Leck AB, pilot ejected to safety
24.03.1964	DC+101	2071	F-104G	JaboG 33	heavy damaged after take-off abort due to nose wheel shimmy, pilot (USAF) was safe
02.05.1964	JA+106	8018	F-104G	JG 71	crashed into ground during slow flight demonstration at Armed Forces Day Bremerhaven, pilot (USAF) was killed
11.05.1964	JA+232	8036	F-104G	JG 71	hit the approach lights on final at Wittmundhafen AB in bad weather (heavy rain), pilot was killed
11.05.1964	EA+233	8142	RF-104G	AG 51	Engine failure shortly after take-off at Manching AB, pilot ejected safely
27.07.1964	BB+380	5067	F-104F	WaSLw 10	Loss of aircraft control near Hesel after loosing a flap at high speed, pilots (AMI) ejected safely
14.10.1964	DD+237	7136	F-104G	JaboG 34	Hit some trees due to disorientation after an TACAN instrument approach into Memmingen AB (CFIT), pilot was killed
16.10.1964	DC+236	2085	F-104G	JaboG 33	engine explosion with strong vibrations and loss of aircraft control near Mühlhausen, France, pilot ejected safely
12.11.1964	EA+115	8126	RF-104G	AG 51	engine explosion and engine failure during GCA at Manching AB, pilot (USAF) ejected safely

24.02.1965	BB+239	8189	RF-104G	WaSLw 10	ground contact after Afterburner blow-out shortly after take-off from Jever AB, pilot was killed
18.03.1965	VA+116	7096	F-104G	MFG 1	ditching (water contact) during sea low level near Büsum (CFIT), pilot was killed
18.03.1965	JA+107	8041	F-104G	JG 71	heavy damaged in open field after take-off abort and barrier failure, pilot was safe
19.03.1965	EA+243	8155	RF-104G	AG 51	ground contact during recce low level in poor weather near Kaufbeuren AB (CFIT), pilot was killed
16.04.1965	62-12312	6011	F-104G	4510 CCTW	loss of aircraft control after take-off from Luke AFB, canopy not fully locked, German Navy pilot was killed (MAP aircraft)
23.04.1965	EA+108	8108	RF-104G	AG 51	lightning strike and engine failure near Vilsbiburg during GCA-approach to Ingolstadt, pilot ejected safely
26.04.1965	TA+163	5729	TF-104G	MFG 1	nozzle failure and power loss during GCA into Jagel AB, both pilots ejected safely
13.05.1965	63-13236	2018	F-104G	4510 CCTW	ground contact during recovery (pull up) in a gunnery event at Gila Bend range (CFIT), pilot was killed
11.06.1965	JA+235	8039	F-104G	JG 71	ground contact after disorientation in clouds during a Low Level flight, pilot was killed
12.06.1965	DA+259	9047	F-104G	JaboG 31	compressor stall (IGV failure) during range sortie at Suippes Range, France, pilot ejected safely
14.06.1965	DF+123	9149	F-104G	JaboG 36	engine explosion and engine failure near Köhlen, Wesermünde, pilot ejected but died shortly afterwards (C-2 ejection seat limits)
22.06.1965	EA+120	8136	RF-104G	AG 51	gear and flaps problems shortly after take-off at Laon AB, France, pilot was killed
29.06.1965	DC+126	7071	F-104G	JaboG 33	disorientation after lightning strike during high altitude navigation flight near Grossouire, France, pilot ejected safely
02.07.1965	63-13230	2011	F-104G	4510 CCTW	pitch-up almost vertical after take-off configured as dart tow, USAF pilot was killed
06.07.1965	63-13248	2032	F-104G	4510 CCTW	loss of control during recovery in a gunnery event at Gila Bend range, pilot was killed
03.08.1965	BB+247	8198	RF-104G	WaSLw 10	ground contact in bad weather during Low Level at Halle, near Bielefeld (CFIT), pilot was killed
04.08.1965	DA+253	7104	F-104G	JaboG 31	caught fire in the barrier after take-off abort due to communication problems with tower at Norvenich AB, pilot was safe
17.08.1965	BB+364	5051	F-104F	WaSLw 10	broken right landing gear strut during night landing at Jever AB, both pilots ejected safely
23.08.1965	EA+126	8171	RF-104G	AG 51	loss of control during take-off at Manching AB due to broken elevator pin, pilot was killed
22.09.1965	JD+248	8228	F-104G	JG 74	nozzle failure and power loss during GCA into Jever AB, pilot ejected but was drowned
22.09.1965	BB+246	8197	RF-104G	WaSLw 10	engine failure due to fuel starvation during approach to Jever AB, pilot ejected safely
29.09.1965	DA+114	7018	F-104G	JaboG 31	engine failure due to loss of oil during approach to Jever AB, pilot ejected but died
05.11.1965	DD+120	7128	F-104G	JaboG 34	disorientation after entering clouds shortly after take-off in formation at Memmingen AB, pilot was killed
24.11.1965	DD+119	7127	F-104G	JaboG 34	caught fire after loosing hydraulic fluid over Frasca Range, Sardegna, pilot ejected safely
06.12.1965	DA+254	7105	F-104G	JaboG 31	pilot got incapacitated and died due to oxygen problems, aircraft flew on Autopilot and crashed near Narwik, Norway
22.12.1965	JD+106	9066	F-104G	JG 74	fuel depletion being unable to land in snow storm at Neuburg or Manching AB, pilot ejected safely
23.12.1965	DB+234	8315	F-104G	JaboG 32	spatial disorientation after vertigo in bad weather near Laichingen, pilot did not eject and was killed
20.01.1966	JA+123	8016	F-104G	JG 71	nozzle failure after take-off from Wittmundhafen for a test flight, pilot ejected but died on parachute landing fall
07.02.1966	BB+249	8201	RF-104G	WaSLw 10	broken right main landing gear prior landing at Jever AB, controlled bail out, pilot ejected safely
11.02.1966	DA+240	2061	F-104G	JaboG 31	heavy damaged after ground contact in fog 800 m short of runway at Norvenich AB, pilot was seriously injured
03.03.1966	63-13270	8003	F-104G	4510 CCTW	fuel system malfunction after flying a barrel roll during 1st night solo flight near Luke AFB, pilot ejected safely
10.03.1966	DC+117	2074	F-104G	JaboG 33	crashed shortly after take-off from Buchel AB for unknown reason (possible APC problem), pilot was killed
18.03.1966	DB+237	8320	F-104G	JaboG 32	engine failure after a compressor stall on take-off during gear retraction at Lechfeld AB, pilot ejected but died
21.03.1966	EB+112	8210	RF-104G	AG 51	loss of control and entered spin during test flight (APC malfunction), pilot ejected safely
02.05.1966	VA+104	7084	F-104G	MFG 1	compressor stall with engine failure after take-off, pilot ejected at 1500 feet, but the parachute malfunctioned
10.05.1966	VA+115	7095	F-104G	MFG 1	midair collision in bad weather with construction number 7197 over the North Sea, near Terschelling, NL, pilot was killed
10.05.1966	VB+240	7197	F-104G	MFG 2	midair collision in bad weather with construction number 7095 over the North Sea, near Terschelling, NL, pilot ejected but died
17.05.1966	DA+129	9059	F-104G	JaboG 31	damaged after emergency landing with open nozzle at RAF Gutersloh, cutting the net barrier, pilot was injured

27.05.1966	DF+234	9157	F-104G	JaboG 36	weered off the runway after chute failure during landing at Hopsten AB, pilot ejected but died from fatal injuries
27.05.1966	63-13259	2010	F-104G	4510 CCTW	engine failure due to open nozzle, caused by loss of oil pressure, Gila Bend Bombing Range, AZ, USA, pilot ejected safely
13.06.1966	EA+107	8106	RF-104G	AG 51	midair collision with construction number 8160 over Zuider Sea, Netherlands, pilot ejected but died after the ejection
13.06.1966	EA+248	8160	RF-104G	AG 51	midair collision with construction number 8106 over Zuider Sea, Netherlands, pilot did not eject and was killed
13.07.1966	63-13277	9004	F-104G	4510 CCTW	loss of control and ground contact during recovery in a Gunnery event at Gila Bend range (CFIT), pilot was killed
18.07.1966	JA+254	8078	F-104G	JG 71	loss of aircraft control during A/A Gunnery pass approaching the tow target near Helgoland island, pilot ejected but was drowned
19.07.1966	DD+232	7131	F-104G	JaboG 34	over-G in the landing at Memmingen due to oxygen problems (incapacitated pilot), pilot was safe
15.09.1966	63-13261	8196	F-104G	4510 CCTW	asymmetric flaps and loss of aircraft control after take-off, pilot ejected safely
16.09.1966	63-13241	2024	F-104G	4510 CCTW	flight control problems after take-off, pilot ejected but got hit by his ejection seat and died
18.10.1066	VA+145	7169	F-104G	MFG 1	compressor stall over sea near Isle Neuwerk, pilot ejected but was injured
28.11.1966	DC+126	8292	F-104G	JaboG 33	crashed on landing at Buchel AB due to BLC failure, pilot ejected but died afterwards
07.02.1967	DA+256	7107	F-104G	JaboG 31	spatial disorientation after vertigo departing Capo Frasca Bombing Range, pilot was killed
03.03.1967	DC+119	2077	F-104G	JaboG 33	loss of control in the landing pattern at Decimomannu AB (APC system was deactivated), pilot ejected and was injured
16.03.1967	*JA+101*	*9080*	*F-104G*	*JG 71*	*emergency landing at Wittmund AB heavy damaged due to lightning strike; damaged beyond repair; reactivated 1968!*
28.04.1967	VB+205	6641	RF-104G	MFG 2	bird strike during Low Level flight near Bad Meinberg, pilot ejected safely
16.05.1967	EB+256	8276	RF-104G	AG 52	bird strike during Low Level flight at Neufeld, near Helserdeich, Süderdithmarschen, pilot ejected safely
22.05.1967	VA+133	7157	F-104G	MFG 1	crashed at Lommersum due to compressor stall (FOD) after take-off from Norvenich AB, pilot ejected safely
29.05.1967	DF+361	5915	TF-104G	JaboG 36	loss of electrical system and fire warning near Hopsten AB, pilots ejected safely
08.06.1967	EA+252	6627	RF-104G	AG 51	nozzle failure during approach into Manching AB, pilot ejected safely
15.08.1967	JA+240	8044	F-104G	JG 71	left runway and flipped over during night landing at Wittmundhaven, pilot unhurt; declared damaged beyond repair at Messerschmitt
19.09.1967	DC+231	8328	F-104G	JaboG 33	nozzle failure and emergency landing at Korfu AB, pilot ejected 10 feet under water
13.10.1967	DA+231	7030	F-104G	JaboG 31	nozzle failure in bad weather during approach into Norvenich AB, pilot ejected safely
24.10.1967	63-13239	2022	F-104G	4510 CCTW	midair collision with construction number 2096 during formation rejoin after ACM mission near Ajo, Arizona, pilot ejected safely
24.10.1967	63-13267	2096	F-104G	4510 CCTW	midair collision with construction number 2022 during formation rejoin after ACM mission near Ajo, Arizona, pilot ejected safely
07.12.1967	DF+361	5944	TF-104G	JaboG 36	nozzle failure during approach into Hopsten AB in snow storm, both pilots were killed
25.01.1968	25+01	8254	RF-104G	AG 52	exploded in midair after engine fire after "touch and go" at Leck AB after a night flight, pilot ejected safely
27.03.1968	20+66	2078	F-104G	JaboG 33	engine failure due to compressor stall right after take-off from Buchel AB, pilot ejected ok and was injured
04.04.1968	22+27	7102	F-104G	MFG 1	spatial disorientation (suspected unconscious) during approach to Jagel AB after a Low Level flight, pilot was killed
17.04.1968	21+73	7042	F-104G	JaboG 32	exploded in midair during Mach 2 functional test flight, exploded after cockpit-depressurization above 50.000 ft, pilot was killed
21.05.1968	21+08	6630	RF-104G	MFG 2	spatial disorientation after vertigo in bad weather during low level formation flight near Silberstedt, pilot was killed
28.05.1968	27+04	5705	TF-104G	WaSLw 10	loss of thrust control due to broken throttle linkage to the fuel control near Wittmundhafen AB, pilots ejected safely
11.06.1968	24+50	8194	F-104G	JaboG 34	crashed into mountain due to failure of navigation system (nighttime), pilot was killed
20.06.1968	20+09	2009	F-104G	JG 71	loss of aircraft control CFIT) after a barrel roll at Dornum in the Wittmund landing pattern, pilot ejected safely
02.08.1968	65-12749	8064	F-104G	4510 CCTW	ground contact after pitch-up during recovery (late pull-out) in a gunnery event at Gila Bend range, pilot was killed
05.08.1968	63-13274	9001	F-104G	4510 CCTW	asymmetric Flaps (split Flaps) and loss of aircraft control near Luke AFB in the landing pattern, pilot ejected safely
22.08.1968	*21+05*	*6626*	*RF-104G*	*AG 51*	*ground loss: caught on fire during engine test run at Manching AB, written off*
22.08.1968	*24+14*	*8154*	*RF-104G*	*AG 51*	*ground loss: caught on fire from burning construction number 6626 during engine test at Manching AB, written off*

18.09.1968	23+04	7187	F-104G	MFG 2	water contact (CFIT) during Sea Low Level in the Kattegat near island Anholt, pilot ejected and was rescued but died later
24.09.1968	22+02	7072	F-104G	JaboG 33	damaged after emergency landing at Ramstein AB, pilot slightly injured; 1. Martin Baker GQ-7 ejection!
24.09.1968	25+77	9041	F-104G	JG 71	loss of aircraft control with departure into a spin near Wittmundhafen AB, pilot ejected
09.10.1968	28+21	5951	TF-104G	WaSLw 10	water contact in river Weser during formation exercise near Weddewarden, both pilots died
09.10.1968	21+62	7031	F-104G	JaboG 31	crashed into terrain in bad weather near Ottmarsbocholt, pilot was killed
25.11.1968	*26+14*	*9155*	*F-104G*	*JaboG 36*	*ground loss: caught on fire during engine test run at Hopsten AB, written off*
12.12.1968	23+10	7193	F-104G	MFG 2	crashed into North Sea after bird strike near Helgoland, pilot ejected but drowned
05.03.1969	21+66	7035	F-104G	JaboG 34	engine failure after compressor blade failure during functional test flight, pilot ejected safely
05.03.1969	65-12746	8021	F-104G	4510 CCTW	loss of right wing and loss of control at Gila Bend range, pilot was killed
25.03.1969	67-14891	8191	F-104G	4510 CCTW	asymmetric land flaps and loss of aircraft control at Luke AFB, pilot ejected and was seriously injured
15.04.1969	27+32	5734	TF-104G	JG 71	compressor stall during functional test flight, one pilot ejected ok, one pilot was killed
30.04.1969	20+45	2053	F-104G	JaboG 31	damaged after emergency landing due to engine fire, pilot was ok
22.05.1969	63-13268	2097	F-104G	4510 CCTW	loss of aircraft control during first solo flight near Lake Havasu, pilot was killed
09.06.1969	21+59	7028	F-104G	JaboG 31	nozzle failure during approach into Buchel AB, pilot was killed
08.07.1969	66-13623	5934	TF-104G	4510 CCTW	engine failure during gunnery sortie at Gila Bend Range, one pilot ejected safely, one pilot was hit by a ejection seat and killed
11.07.1969	63-13263	2091	F-104G	4510 CCTW	midair collision with construction number 7120 during formation rejoin near Wickenburg, AZ, pilot ejected safely
30.07.1969	20+51	2059	F-104G	JaboG 31	caught fire in open field after take-off abort due to wrong airspeed indication and barrier failure at Norvenich AB, pilot ejected safely
27.08.1969	21+77	7046	F-104G	JaboG 36	nozzle failure after take-off from Hopsten AB, pilot was killed
15.09.1969	23+80	8080	F-104G	JG 71	spatial disorientation during night flight near Leer, pilot ejected but died
13.10.1969	22+34	7112	F-104G	JaboG 34	loss of aircraft control by entering a spin during a functional test flight, pilot ejected to safety
29.10.1969	63-8466	5773	TF-104G	4510 CCTW	engine oil problems after a looping, one pilot ejected safely, US IP was killed (no chute, seat separation for IP failed)
31.10.1969	26+09	9143	F-104G	JaboG 36	caught fire in open field after take-off abort and barrier failure, pilot ejected safely over the runway
05.11.1969	24+08	8148	RF-104G	AG 52	lightning strike after take-off from Leck AB, pilot ejected but was drowned in the river Weser and died due to hypothermia
22.01.1970	21+89	7058	F-104G	JaboG 32	midair collision with construction number 8323 near Landsberg AB, pilot ejected but died lateron
22.01.1970	25+39	8323	F-104G	JaboG 32	midair collision with construction number 7058 near Landsberg AB, pilot ejected safely
04.02.1970	63-13246	2030	F-104G	58 TFTW	loss of aircraft control during flight near Ajo, Arizona, pilot ejected and was seriously injured
06.03.1970	29+13	5064	F-104F	WaSLw 10	gear raised too early after "touch and go" at Jever AB, both pilots ejected safely
10.03.1970	21+28	6689	RF-104G	MFG 2	spatial disorientation during GCA into Eggebek AB, pilot was killed
19.03.1970	24+32	8175	RF-104G	AG 51	loss of aircraft control to avoid another aircraft near Singen, pilot ejected safely
24.03.1970	61-3077	5748	TF-104G	58 TFTW	gear was raised too early after "touch and go", caught fire after barrier engagement at Luke AFB, both pilots were rescued safely
21.04.1970	25+60	9006	F-104G	JG 71	emergency landing at RAF Wildenrath after engine seizure (no fuel), pilot ejected safely over the runway
05.05.1970	23+93	8111	RF-104G	AG 51	crashed into mountain during a Reconnaissance Low Level mission near Singen, pilot was killed
08.05.1970	63-13233	2014	F-104G	58 TFTW	loss of control during recovery in a gunnery event due to trim failure, pilot was killed
22.05.1970	24+41	8184	F-104G	JaboG 34	lightning strike during GCA into Memmingen AB, pilot ejected safely
02.06.1970	21+12	6661	RF-104G	MFG 2	nose wheel steering failure and brake failure during landing at Eggebek AB, pilot was not hurt, damage beyond repair
25.08.1970	27+30	5732	TF-104G	MFG 1	engine failure due to FOD after take-off from Jagel AB, pilots ejected safely
03.09.1970	26+27	9179	F-104G	JaboG 36	ground contact during a simulated attack on Bergen-Hohne range, pilot was killed
22.10.1970	67-14886	7023	F-104G	58 TFTW	engine failure due to FOD during Air/Air Gunnery mission on Gila Bend Range, west of Ajo, AZ, USAF pilot (IP) ejected safely

30.10.1970	**21+87**	**7056**	**F-104G**	**JaboG 32**	**engine failure due to bird strike near Holzkirchen, Bavaria, pilot ejected safely**
12.11.1970	**20+52**	**2060**	**F-104G**	**JaboG 31**	**loss of aircraft control (CFIT) during A/G gunnery event on Helchteren Range, BE; pilot was killed**
14.12.1970	**29+11**	**5061**	**F-104F**	**WaSLw 10**	**landing gear failed on emergency landing due to bird strike at Soesterberg AB, Netherlands, both pilots ok; damaged beyond repair**
19.01.1971	**26+22**	**9173**	**F-104G**	**JaboG 31**	**compressor stall due to FOD after take-off and engine failure on final at Norvenich AB, pilot ejected safely**
26.02.1971	**22+64**	**7145**	**F-104G**	**Det Deci**	**engine failure due to FOD (ricochets) during gun firing on Frasca Bombing Range, pilot ejected to safety**
04.03.1971	**24+37**	**8180**	**RF-104G**	**AG 51**	**main landing gear broke on emergency landing at Memmingen, controlled ejection, pilot ejected safely**
05.03.1971	**27+78**	**5907**	**TF-104G**	**MFG 2**	**ground contact during a Low Level mission at Syke, near Bassum (CFIT), both pilots were killed**
09.03.1971	**26+36**	**9188**	**F-104G**	**JaboG 36**	**compressor stall and engine failure during a Low Level mission at Hinnekamp, near Damme, pilot ejected and was injured**
12.03.1971	**25+85**	**9060**	**F-104G**	**JaboG 33**	**engine failure after gunnery on Frasca range, pilot ejected safely**
18.03.1971	**23+63**	**8046**	**F-104G**	**JG 71**	**loss of aircraft control during approach into Wittmundhafen AB, pilot ejected but died**
23.03.1971	**23+14**	**7198**	**F-104G**	**MFG 2**	**engine failure after lightning strike during instrument approach into Decimonannu AB, pilot ejected safely**
23.03.1971	**29+15**	**5068**	**F-104F**	**WaSLw 10**	**BLC failure and loss of control during landing, both pilots killed; all F-104F grounded and withdrawn from service on April 16, 1971**
16.04.1971	**25+72**	**9030**	**F-104G**	**JG 74**	**nozzle failure due to loss of oil near Donauwörth, pilot ejected safely**
30.04.1971	**24+82**	**8232**	**F-104G**	**JaboG 31**	**compressor stall and engine failure after take-off from Norvenich AB, pilot ejected safely**
27.05.1971	**22+76**	**7158**	**F-104G**	**MFG 2**	**engine failure after problems in the fuel system near Borkum, pilot ejected to safety**
28.07.1971	**25+21**	**8295**	**F-104G**	**JaboG 32**	**weered off runway with broken landing gear at Decimomannu AB, pilot was ok**
19.08.1971	***23+13***	***7196***	***F-104G***	***MFG 2***	***ground loss: caught on fire during system test after jettisoned tank at Eggebek AB, written off***
21.09.1971	**21+46**	**7014**	**F-104G**	**JaboG 31**	**caught fire after take-off due to hydraulic fluid entering the engine, pilot ejected safely**
14.10.1971	**21+10**	**6640**	**RF-104G**	**MFG 2**	**spatial disorientation in heavy rain during approach to Capo Frasca Bombing Range (CFIT), pilot was killed**
08.11.1971	**63-13247**	**2031**	**F-104G**	**58 TFTW**	**compressor stall and engine failure after A/A gunnery on Gila Bend, pilot ejected safely**
17.11.1971	**24+93**	**8246**	**F-104G**	**JG 74**	**ground contact during GCA into Neuburg AB at nighttime after oxygen system failure at altitude, pilot was killed**
19.11.1971	***24+71***	***8220***	***F-104G***	***JG 74***	***ground loss: caught on fire during system test at Neuburg AB, written off***
31.01.1972	***20+40***	***2047***	***F-104G***	***JaboG 34***	***ground loss: caught on fire during fueling after explosion of a fuel tank at Memmingen AB, written off***
11.02.1972	**24+86**	**8236**	**F-104G**	**JG 74**	**crash landing after nozzle failure at Neuburg AB, pilot ejected safe over the runway**
16.02.1972	**26+59**	**7405**	**F-104G**	**MFG 2**	**ground contact during gunnery on Terschelling range (CFIT), pilot was killed**
17.02.1972	**27+91**	**5921**	**TF-104G**	**WaSLw 10**	**hit trees on GCA final into Jever AB, one pilot ejected ok, one pilot was killed**
08.03.1972	**23+89**	**8096**	**F-104G**	**JG 71**	**loss of aircraft control during landing at Wittmundhafen AB, pilot ejected safely**
16.03.1972	**22+33**	**7111**	**F-104G**	**JaboG 34**	**ground contact during recovery during gunnery at Siegenburg range (CFIT), pilot ejected safely**
11.04.1972	**20+95**	**6616**	**F-104G**	**JG 74**	**engine failure due to open nozzle during approach into Neuburg AB, pilot was killed**
31.05.1972	**24+30**	**8173**	**F-104G**	**JG 74**	**loss of aircraft control during ACM (pitch-up), pilot ejected safely**
12.06.1972	**25+20**	**8291**	**F-104G**	**JaboG 31**	**disorientation after lightning strike at Neede, near Enschede, Netherlands, pilot was killed**
22.06.1972	**65-12752**	**8069**	**F-104G**	**58 TFTW**	**loss of aircraft control after entering clouds during loop near Wickenburg, pilot was killed**
25.08.1972	**28+17**	**5947**	**TF-104G**	**JG 74**	**crash landing after high sink rate at Upper Heyford AB, pilot ejected safe over runway**
01.12.1972	**67-14888**	**7007**	**F-104G**	**58 TFTW**	**loss of aircraft control during roll-in for a practice tactical Rockets-delivery at Gila Bend range Nr.1, pilot was killed**
01.02.1973	**24+10**	**8150**	**F-104G**	**JaboG 34**	**engine failure due to open nozzle during emergency approach into Memmingen AB, pilot was killed**
22.02.1973	**24+44**	**8187**	**F-104G**	**JaboG 33**	**crash landing after hydraulic failure at Buchel AB, pilot ejected over the runway**
12.03.1973	**27+28**	**5730**	**TF-104G**	**JG 71**	**gear up landing during "touch and go" at Jever AB, pilots were both ok**
04.04.1973	***21+76***	***7045***	***F-104G***	***Det Deci***	***ground loss: caught on fire during ground system test at Decimomannu AB, written off***

05.04.1973	67-14893	8177	F-104G	58 TFTW	ground collision after a too steep delivery angle at a gunnery event at Gila Bend Range #1 (CFIT), pilot was killed, no ejection attempt
10.04.1973	20+41	2048	F-104G	JaboG 31	loss of aircraft control with chute failure after landing at Norvenich AB, pilot was safe
12.04.1973	21+97	7066	F-104G	JaboG 33	after unsuccessful landing attempt with nozzle failure in snow storm at Buchel AB, pilot made a safe precautionary controlled ejection
24.04.1973	24+39	8182	F-104G	JaboG 36	left runway after blown tire on take-off at Hopsten AB, pilot was badly injured
01.06.1973	23+52	8031	F-104G	JG 71	compressor stall and engine failure after take-off from Memmingen, pilot ejected safely
15.06.1973	20+55	2064	F-104G	JaboG 31	engine fire during start-up at Beja AB, Portugal, after explosion of starter cart unit, pilot was safe
19.07.1973	23+75	8074	F-104G	MBB	asymmetric flaps after flap drive unit failure and loss of aircraft control during test flight, pilot ejected safely
29.08.1973	63-13276	9003	F-104G	58 TFTW	midair collision with construction number 8077 during rejoin near Ajo, AZ, pilot ejected but was killed due to parachute malfunction
29.08.1973	65-12754	8077	F-104G	58 TFTW	midair collision with construction number 9003 during rejoin near Ajo, AZ, pilot ejected but was killed due to parachute malfunction
26.10.1973	26+50	7310	F-104G	JaboG 31	ground contact during recovery on Helchteren range, pilot was killed
22.11.1973	28+26	5956	TF-104G	WaSLw 10	engine failure near the island Langeroog, pilots ejected to safety
19.02.1974	26+64	7410	F-104G	MFG 2	engine failure during gunnery on Terschelling range, Netherlands, pilot ejected safely
11.03.1974	21+48	7016	F-104G	JaboG 31	compressor stall and engine failure during approach into Norvenich, pilot ejected safely
12.03.1974	28+00	5930	TF-104G	WaSLw 10	gear raised too early after "touch and go" at Jever AB, pilots ejected safely
20.03.1974	26+84	7430	F-104G	MFG 1	water contact during simulated attack on Navy ships near Damp, pilot was killed
27.03.1974	63-8453	5757	TF-104G	58 TFTW	loss of nose gear steering and anti-skid system during landing roll, both pilots were ok
17.04.1974	26+71	7417	F-104G	MFG 2	loss of aircraft control during an Air Combat Maneuvering (ACM) mission, pilot ejected, but was killed on landing (parachute damaged)
17.04.1974	25+76	9037	F-104G	JaboG 31	crash landing after engine failure at Norvenich AB, pilot ejected safely over the runway
23.04.1974	24+09	8149	F-104G	JaboG 36	over-G during high performance training flight at Beja, Portugal, pilot ejected but was badly injured
09.09.1974	23+41	8019	F-104G	JaboG 31	compressor stall (due to FOD) and engine failure on approach into Norvenich AB at night, pilot ejected to safety
10.12.1974	26+48	7308	F-104G	JaboG 32	hit the approach lights on short final at Lechfeld AB, pilot ejected safely over the runway
14.01.1975	61-3081	5752	TF-104G	58 TFTW	loss of aircraft control after hydraulic failure during ACM, both pilot were killed during supersonic ejection
18.02.1975	63-13275	9002	F-104G	58 TFTW	asymmetric flight condition and loss of aircraft control at Gila Bend range, pilot was killed
24.04.1975	22+09	7079	F-104G	JaboG 34	ground contact during practice low level formation exercise (CFIT), pilot was killed
01.07.1975	63-13231	2012	F-104G	58 TFTW	out of control after engine failure (FOD) on take-off with asymmetrical load, pilot US IP was killed
09.07.1975	63-13256	2040	F-104G	58 TFTW	compressor stall and engine failure after take-off on a test flight, pilot ejected safely
23.07.1975	20+77	2090	F-104G	Det Deci	compressor stall and engine failure during approach to Decimomannu AB, pilot ejected and was injured
06.08.1975	24+61	8209	F-104G	Det Deci	water contact (ditching) during A/G gunnery at Frasca range (CFIT), pilot was killed
22.08.1975	22+75	7156	F-104G	MFG 1	midair collision with construction number 8178 near Eiderststedt, pilot was killed
22.08.1975	24+35	8178	F-104G	MFG 2	midair collision with construction number 7156 near Eiderststedt, pilot was killed
04.09.1975	25+73	9031	F-104G	Det Deci	engine failure due to FOD after take-off from Decimomannu AB, pilots ejected to safety
20.09.1975	22+28	7103	F-104G	MFG 1	damaged after emergency landing with open nozzle at Skydstrup AB, pilot ejected to safety on the runway
30.01.1976	63-13258	2042	F-104G	58 TFTW	loss of aircraft control after uncontrolled stick movements, pilot ejected safely
06.02.1976	66-13624	5935	TF-104G	58 TFTW	loss of aircraft control after loosing forward wing flap on Gila Bend Bombing Range, AZ, USA, both pilots ejected safely
24.02.1976	21+40	7008	F-104G	JaboG 34	crashed after emergency landing with minimum fuel and tailwind at Manching AB, collided with a telemetry box, pilot was injured
10.03.1976	63-13237	2020	F-104G	58 TFTW	engine failure due to FOD (ricochet) on Gila Bend Range, pilot ejected safely
15.03.1976	26+73	7419	F-104G	MFG 2	engine failure due to bird strike near St.Peter-Ording, pilot ejected to safety
18.03.1976	66-13524	7120	F-104G	58 TFTW	ground contact after loss of aircraft control on Gila Bend Bombing Range, AZ, USA (CFIT), pilot was fatally injured

16.06.1976	26+16	9161	F-104G	JaboG 32	mid air collision after loss of aircraft steering in a 3 ship formation (in IMC) near Mindelheim, pilot ejected safely
20.06.1976	20+03	2003	F-104G	JaboG 31	loss of aircraft control after hydraulic failure in approach to Norvenich, pilot was killed
10.08.1976	26+18	9163	F-104G	JaboG 34	broken left main landing gear after hard landing, controlled ejection, pilot was safe
24.08.1976	21+84	7053	F-104G	JaboG 32	loss of control with pitch-up after "Over-G" near Leipheim, pilot ejected safely
30.08.1976	27+75	5904	TF-104G	JaboG 33	loss of aircraft control during ACM near Adenau, pilots ejected safely
20.09.1976	21+79	7048	F-104G	JaboG 32	loss of aircraft control during ACM near Giengen, pilot ejected safely
24.02.1977	20+63	2073	F-104G	JaboG 33	water contact (ditching) during gunnery on Terschelling Range, Netherlands (CFIT), pilot was killed
03.03.1977	22+66	7147	F-104G	JaboG 31	compressor stall due to FOD (safety pin) and engine failure during low level near Leeuwarden, Netherlands, pilot ejected, but was injured
19.04.1977	21+14	6663	RF-104G	MFG 2	engine failure after bird strike during sea low level near Moen, Denmark, pilot ejected safely
05.05.1977	21+51	7020	F-104G	JaboG 34	spatial disorientation after vertigo in bad weather near Kempten, pilot was killed
02.06.1977	26+77	7423	F-104G	MFG 2	crashed into sea ground contact during gunnery on Terschelling Range, pilot was killed
11.07.1977	63-13232	2013	F-104G	58 TFTW	crashed during Emergency Landing after compressor stall and engine failure during gunnery on Gila Bend Range, pilot ejected safely
02.08.1977	21+41	7009	F-104G	JaboG 34	midair collision with a glider near Neuenahr, pilot ejected but was injured, glider pilot ok
09.08.1977	26+06	9134	F-104G	JaboG 31	damaged after emergency landing due to engine vibrations after takeoff at RAF Lossiemouth, UK, pilot was ok
07.10.1977	28+18	5948	TF-104G	JaboG 33	engine failure after bird strike near Bad Schwalbach, both pilots ejected to safety
12.10.1977	20+54	2063	F-104G	JaboG 31	crashed after disorientation during night bomb delivery at Nordhorn Range, pilot was killed
24.01.1978	25+75	9036	F-104G	JaboG 31	ground contact during Low Level flight in marginal weather north of Bunde, near Leer (CFIT), pilot was killed
03.03.1978	21+57	7026	F-104G	JaboG 34	engine failure due to oil system problems in approach to Erding AB, pilot ejected safely
20.03.1978	26+46	7306	F-104G	Det Deci	heavy damaged after take-off abort due to broken nose wheel, pilot badly injured
04.04.1978	24+91	8241	F-104G	JaboG 32	loss of aircraft control during final turn for landing at Lechfeld AB, pilot did not eject and was killed
06.04.1978	23+86	8092	F-104G	JaboG 31	loss of aircraft control after simulated forced landing (SFO) at Norvenich AB, pilot ejected safely
20.06.1978	66-13626	5937	TF-104G	58 TFTW	loss of engine control (failure) after broken throttle linkage during pull-out on Gila Bend Range, both pilots ejected safely
21.06.1978	25+16	8285	F-104G	JaboG 33	engine failure during run-in for a simulated attack on Baumholder Army Range, pilot ejected but was badly injured
18.08.1978	21+20	6675	RF-104G	MFG 2	engine failure after bird strike during sea low level east of Helgoland, pilot ejected safely
25.08.1978	25+36	8317	F-104G	JaboG 32	crashed into wood after loss of aircraft control on a BFM training flight, pilot ejected safely
05.09.1978	25+53	8348	F-104G	Det Deci	heavy damaged after crash landing due to high sink rate at Decimomannu, pilot was ok
19.09.1978	23+08	7191	F-104G	MFG 2	bird strike during sea low level in the Kattegat, pilot ejected safely
10.10.1978	25+38	8322	F-104G	JaboG 31	engine failure after bird strike during low level near Nancy, France, pilot ejected to safety
07.12.1978	23+11	7194	F-104G	MFG 2	RF modified; engine failure after bird strike during approach into Eggebek AB, pilot ejected to safety
01.02.1979	22+08	7078	F-104G	JaboG 31	midair collision with construction number 9043 near Norvenich AB, pilot ejected safely, the other pilot landed
05.02.1979	22+84	7166	F-104G	MFG 1	engine failure during gunnery at List/Sylt Range, pilot ejected safely
14.03.1979	26+32	9184	F-104G	JaboG 34	engine failure due to FOD after take-off from Memmingen AB, pilot ejected to safety
17.04.1979	22+15	7086	F-104G	MFG 1	engine failure after bird strike during low level near St.Peter Ording, pilot ejected to safety
06.07.1979	63-13250	2034	F-104G	58 TFTW	engine failure after fuel control failure (false maintenance on fuel pump) during gunnery on Gila Bend, pilot ejected to safety
03.08.1979	22+25	7100	F-104G	MFG 1	crashed after over-G during landing after performance demonstration at Yeovilton, UK, pilot was killed
06.09.1979	27+99	5929	TF-104G	MFG 2	crashed after flight control problems over Lüneburger Heide, both pilots ejected to safety
01.10.1979	25+10	8271	F-104G	JaboG 34	compressor stall and engine failure at Allenbach near Birkenfeld, pilot ejected to safety
09.11.1979	23+20	7204	F-104G	MFG 2	loss of aircraft control at Haselund, near Flensburg, pilot ejected to safety

13.11.1979	27+05	5706	TF-104G	WaSLw 10	loss of aircraft control after selection of land flaps at high speed, both pilots ejected to safety
05.02.1980	25+82	9053	F-104G	Det Deci	water contact (ditching) during gunnery at Capo Frasca Range, pilot was killed
04.03.1980	20+15	2017	F-104G	JaboG 31	spatial disorientation in bombing pattern at Helchteren Range, pilot ejected safely
13.03.1980	22+31	7109	F-104G	JaboG 34	contact with power line during low level flight in poor weather conditions (CFIT), pilot was killed
01.07.1980	22+54	7134	F-104G	JaboG 34	contact with power line mast during simulated attack on Army tank (CFIT), pilot was killed
08.07.1980	24+28	8170	F-104G	WaSLw 10	water contact (ditching) during gunnery at Capo Frasca Range (CFIT), pilot was killed
22.09.1980	22+78	7160	F-104G	MFG 1	ground contact (CFIT) during Radar Low Level mission in bad weather, pilot was killed
08.10.1980	26+35	9187	F-104G	JaboG 34	midair collision with construction number 8208 during attack on Sollingen AB, pilot was killed
08.10.1980	24+60	8208	F-104G	JaboG 34	midair collision with construction number 9187 during attack on Sollingen AB, emergency landing, pilot was ok, written off
17.10.1980	24+72	8221	F-104G	JaboG 31	caught fire after hot afterburner fuel-pump near Hürth, pilot ejected to safety
04.12.1980	20+58	2067	F-104G	JaboG 31	midair collision with cn 7011 during approach to Wildenrath AB, emergency landing; damaged beyond economical repair
04.12.1980	21+43	7011	F-104G	JaboG 31	midair collision with construction number 2067 during approach to Wildenrath AB, pilot ejected safely
18.05.1981	24+79	8229	F-104G	JaboG 32	ground contact (CFIT) during gunnery on Heuberg Army Range, pilot was killed
06.07.1981	24+58	8206	F-104G	JaboG 33	engine failure after bird strike during low level near Staigerbach, Hohenlohe, pilot ejected safely
14.07.1981	63-8459	5763	TF-104G	58 TFTW	loss of engine control after broken throttle linkage at Aguila, near Wickenburg, Arizona, both pilots ejected to safety
04.08.1981	66-13525	7132	F-104G	58 TFTW	engine failure due to FOD (ricochet) during A/G gunnery on Gila Bend Range, pilot ejected to safety
17.08.1981	25+79	9043	F-104G	JaboG 33	engine failure and compressor stall during low level at Verdun, France, pilot ejected to safety
25.08.1981	24+29	8172	F-104G	JaboG 33	bird strike during "touch and go" at Beja AB, pilot ejected, but was badly injured
26.08.1981	26+68	7414	F-104G	MFG 2	engine failure due to bird strike during gunnery on Oskbol Range, Denmark, pilot ejected safely
02.11.1981	20+44	2052	F-104G	Det Deci	overrun the runway after emergency landing with open nozzle at Decimomannu AB, pilot was ok; damaged beyond economical repair
05.11.1981	25+67	9013	F-104G	JaboG 31	heavy damaged after ground contact (CFIT) 300 meter short of runway on final at Norvenich AB, pilot ejected, but died later
28.01.1982	26+54	7314	F-104G	JaboG 34	engine failure due to FOD (ricochet) on Grafenwöhr Army Range, pilot ejected safely
10.02.1982	27+73	5902	TF-104G	JaboG 31	lightning strike on the engine intake and emergency landing at Norvenich AB, pilots were ok; damaged beyond economical repair
21.04.1982	25+54	8349	F-104G	JaboG 32	engine failure after bird strike during Low Level mission at Pan di Zuchero, near Capo Frasca Range, pilot ejected to safety
06.05.1982	27+92	5922	TF-104G	MFG 2	water contact (CFIT) during Sea Low Level mission near Laesoe, DK, pilot and passenger ejected but were killed
01.06.1982	21+93	7062	F-104G	Det Deci	emergency landing at Decimomannu AB after engine vibrations during Night Low Level, pilot ejected safely over the runway
24.06.1982	22+32	7110	F-104G	JaboG 34	loss of aircraft control in low altitude turn with uneven fuel load, pilot was killed
07.07.1982	26+62	7408	F-104G	MFG 2	loss of aircraft control during gunnery on Capo Frasca Range, pilot ejected to safety
04.08.1982	22+48	7126	F-104G	JaboG 34	engine failure due to FOD (lost service panel cover) during Low Level flight near Neumarkt, pilot ejected to safety
26.08.1982	26+10	9144	F-104G	JaboG 33	engine failure after bird strike right after take-off from Erding AB, pilot ejected safely
20.10.1982	22+37	7115	F-104G	Det Deci	engine failure after compressor stall during gunnery at Capo della Frasca Range, pilot ejected to safety
26.10.1982	21+80	7049	F-104G	JaboG 31	water contact (CFIT) during Night Bombing on Vliehors Range, Netherlands, pilot was killed
03.11.1982	26+55	7401	F-104G	MFG 2	engine failure during Sea Low Level in the Kattegat, Denmark, pilot ejected safely
07.12.1982	24+97	8250	F-104G	JaboG 32	crashed with engine problems after take-off from Brawdy AB, pilot ejected safely
10.01.1983	23+87	8094	F-104G	JaboG 31	damaged beyond repair after bird strike and emergency landing at Norvenich AB, pilot was safe
18.03.1983	20+75	2088	F-104G	JaboG 31	damaged beyond repair after bird strike and emergency landing at Norvenich AB, pilot was safe
14.06.1983	28+02	5932	TF-104G	JaboG 34	loss of control during night "touch and go" at Memmingen AB, both pilots ejected to safety
18.07.1983	28+11	5941	TF-104G	JaboG 33	engine failure due to fuel starvation due to closed fuel valve, both pilot ejected to safety

24.01.1984	27+95	5925	TF-104G	JaboG 34	loss of control during landing at Memmingen AB, both pilots ejected to safety
05.04.1984	28+33	5963	TF-104G	JaboG 34	heavy damaged after broken right landing gear strut during taxi at Memmingen AB, damaged beyond economical repair
10.07.1984	23+18	7202	F-104G	MFG 2	loss of aircraft control during formation take-off at Eggebek AB, pilot ejected to safety
10.07.1984	25+62	9008	F-104G	LVR 1	engine failure due to FOD after take-off from Eggebek AB, pilot ejected safely
10.08.1984	22+05	7075	F-104G	JaboG 33	loss of control during high performance training flight at Beja AB, Portugal, pilot ejected and was injured
17.10.1984	23+16	7200	F-104G	MFG 2	RF modified; collision with ship mast during simulated attack on a fast vessel (Schnellboot), pilot was killed
19.10.1984	27+26	5727	TF-104G	JaboG 34	heavy damaged after broken nose gear strut during landing, one pilot ejected ok over the runway
11.12.1984	20+36	2043	F-104G	JaboG 34	spatial disorientation during low level in bad weather near Plattling (CFIT), pilot was killed
08.02.1985	21+27	6688	RF-104G	MFG 2	engine failure due to bird strike during sea low level near Bornholm, pilot ejected safely
18.02.1985	26+70	7416	F-104G	MFG 2	caught fire after midair collision with British Harrier T.4 during low level near Versmold, pilot ejected safely
27.03.1985	21+18	6673	RF-104G	MFG 2	crashed into North Sea due to engine failure after AS.30 missile firing near Helgoland, pilot ejected safely
03.10.1985	23+32	8007	F-104G	JaboG 34	compressor stall during range sortie at Suippes Range, France, pilot ejected safely
03.03.1986	28+10	5940	TF-104G	JaboG 34	engine damage on final at Decimomannu AB, pilot and passenger ejected safely
26.04.1989	28+01	5931	TF-104G	WTD 61	blown tire during "touch and go" at Manching AB, both pilots ejected but were badly injured

German F-104 Losses During Training at Luke AFB (1965-1981)

Source: http://www.916-starfighter.de/GAF_crashes_Luke.htm

Date	Type	Serial	c/n	Comments	Fate of Pilot
16.04.1965	F-104G	62-12312	6011	failed to latch canopy - loss of control after take-off - MAP aircraft	pilot was killed - no ejection
13.05.1965	F-104G	63-13236	2018	gunnery dive angle too steep, recovery too low, ground contact (CFIT); 4518 CCTS	US IP was killed - no apparent attempt to eject
02.07.1965	F-104G	63-13230	2011	flight control system malfunction on take-off, dart tow, pitch-up near vertical; 4518 CCTS	US IP killed - ejected too low, seat separation too late
06.07.1965	F-104G	63-13248	2032	flight control system malfunction - loss of control during gunnery; operated by 4512 CCTS	pilot killed - ejected too low (200 feet AGL in inverted dive)
03.03.1966	F-104G	63-13270	8003	fuel control malfunction during night solo flight, engine failure; operated by 4443 CCTS	pilot ok - safe ejection
27.05.1966	F-104G	63-13259	2010	engine failure due to open nozzle, caused by loss of oil pressure; operated by 4443 CCTS	pilot ejected safely
13.07.1966	F-104G	63-13277	9004	Impacted ground during weapons delivery.	pilot was killed - no apparent attempt to eject
15.09.1966	F-104G	63-13261	8196	asymmetrical flap, loss of control after take-off	pilot ok - safe ejection
16.09.1966	F-104G	63-13241	2024	flight control problems after take-off; operated by 4518 CCTS	US IP was killed - ejected but got hit by his own seat
24.10.1967	F-104G	63-13239	2022	collided with 63-13267 during formation rejoin; operated by 4418 CCTS	pilot ok - safe ejection
24.10.1967	F-104G	63-13267	2096	collided with 63-13239 during formation rejoin; operated by 4418 CCTS	pilot ok - safe ejection
02.08.1968	F-104G	65-12749	8064	loss of control after pitch-up (low pull-out) during weapons delivery; operated by 4418 CCTS	pilot was killed - ejected too low, chute did not deploy
05.08.1968	F-104G	63-13274	9001	asymmetrical flaps, loss of control; operated by 4512 CCTS	pilot was ok - safe ejection
05.03.1969	F-104G	65-12746	8021	loss of right wing and loss of control during pull-up from weapons delivery; 4518 CCTS	pilot was killed - ejection attempted (canopy separated)
25.03.1969	F-104G	67-14891	8191	Asymmetrical flaps on landing, controlled ejection after go-around.	US IP ok - ejected but suffered major injuries
22.05.1969	F-104G	63-13268	2097	lost control after a barrel roll on first solo, ground contact (CFIT); 4512 CCTS	pilot killed - unknown if ejection was attempted
08.07.1969	TF-104G	66-13623	5934	fuel control malfunction, engine failure during weapons delivery; operated by 4512 CCTS	US IP ok, student pilot killed by his ejection seat
11.07.1969	F-104G	63-13263	2091	collided with 66-13524 c/n 7120 (which landed safely) during formation rejoin	pilot ok - safe ejection
29.10.1969	TF-104G	63-8466	5773	engine failure after engine oil problems after a Looping; operated by the 69 TFTS	US IP killed (seat separation failed), student ejected safely
04.02.1970	F-104G	63-13246	2030	pilot handling error and loss of control (CFIT); operated that day by the 69 TFTS (FWS)	pilot ok - safely ejected
24.03.1970	TF-104G	61-3077	5748	Landing gear raised too early doing touch & go, aircraft settled and burned	US IP ok, pilot ok

08.05.1970	F-104G	63-13233	2014	loss of control after trim problems during weapons delivery; operated by the 418 TFTS	German IP killed - ejected too low
22.10.1970	F-104G	67-14886	7023	FOD, engine failure during A/A gunnery; operated by the 69 TFTS	US IP safe ejection
08.11.1971	F-104G	63-13247	2031	gun malfunction caused compressor stall and engine failure; operated by the 69 TFTS	US IP safe ejection
22.06.1972	F-104G	65-12752	8069	lost control during acrobatics (a loop) after entering clouds	pilot killed - unknown if ejection was attempted
01.12.1972	F-104G	67-14888	7007	loss of control during tactical weapons delivery, operated by the 418 TFTS (FWS)	pilot was killed - ejected to late
05.04.1973	F-104G	67-14893	8177	loss of aircraft control during weapons delivery (CFIT), operated by 418 TFTS (FWS)	US IP killed - no apparent attempt to eject
29.08.1973	F-104G	63-13276	9003	collided with 65-12754 c/n 8077 during formation rejoin, operated by 418 TFTS (FWS)	pilot killed - ejection seat system malfunction
29.08.1973	F-104G	65-12754	8077	Collided with 63-13276 c/n 9003 during formation rejoin, operated by 418 TFTS (FWS)	pilot killed - ejection seat system malfunction
27.03.1974	TF-104G	63-8453	5757	landing mishap, anti-skid & nose-wheel steering failed, tire blew; DBR	both US pilots okay
14.01.1975	TF-104G	61-3081	5752	hydraulic failure during ACM	both pilots fatal, supersonic ejection
18.02.1975	F-104G	63-13275	9002	asymmetrical flight condition during weapons delivery, ground contact	pilot fatal injured, no attempt to eject
01.07.1975	F-104G	63-13231	2012	engine failure on T/O (FOD), aircraft burned, DBR; operated by the 69 TFTS	US IP fatal injured, no apparent attempt to eject
09.07.1975	F-104G	63-13256	2040	engine failure after T/O on a test flight after engine change; operated by the 69 TFTS	US IP okay - safe ejection
30.01.1976	F-104G	63-13258	2042	uncommanded pitch down - loss of aircraft control; operated by the 418 TFTS	pilot okay - safe ejection
06.02.1976	TF-104G	66-13624	5935	loss of control after right leading edge flap separated during strafe event, ops 418 TFTS	GAF IP ok, pilot ok
10.03.1976	F-104G	63-13237	2020	ricochet damage, engine failure; operated that day by the 418 TFTS	pilot okay - safe ejection
18.03.1976	F-104G	66-13524	7120	impacted ground during weapons delivery (CFIT); operated by the 418 TFTS	pilot was killed - no ejection was made
11.07.1977	F-104G	63-13232	2013	compressor stall, engine failure during gunnery; operated by the 69 TFTS	US IP okay - safe ejection
20.06.1978	TF-104G	66-13626	5937	throttle control system malfunction (broken throttle linkage); operated by the 69 TFTS	US IP ok, pilot ok
06.07.1979	F-104G	63-13250	2034	fuel control malfunction, engine out; operated by the 69 TFTS	pilot okay - safe ejection
14.07.1981	TF-104G	63-8459	5763	throttle control system malfunction (broken throttle linkage)	US IP ok, pilot ok
04.08.1981	F-104G	66-13525	7132	Ricochet damage, engine failure during weapons delivery; operated by the 69 TFTS	pilot okay - safe ejection

Italian Air Force F-104 Losses (1964-2006)

Date	Serial	Type	Unit	Note
08.01.1964	**6509**	**F-104G**	**4St 9Gr**	**cause unknown, maybe engine failure (compressor stall), pilot was killed**
23.07.1964	**6596**	**F-104G**	**5St 102Gr**	**loss of control during type transitition, pilot was killed**
27.07.1964	**5067**	**F-104F**	**WaSLw 10**	**loss of aircraft control after loosing a flap at high speed near Leer, Germany; both pilots ejected safely; first Italian F-104 ejection, (BB+380, GAF aircraft)**
11.09.1964	**6555**	**F-104G**	**21Gr Auto**	**caught fire after emergency landing with open engine nozzle, pilot was killed**
29.10.1964	**6597**	**F-104G**	**5St 102Gr**	**loss of control after APC malfunction at low level, pilot was injured**
22.01.1965	**6583**	**F-104G**	**5St 102Gr**	**loss of thrust control, IGV closure?, during type transitition, near Todi, pilot was injured**
08.06.1965	**6564**	**F-104G**	**9St 10Gr**	**engine flame out near Vasto, pilot was killed**
25.06.1965	**6659**	**RF-104G**	**FIAT**	**engine flame out for broken linkage, at Carignano near Turin, pilot was injured**
17.08.1965	**6594**	**F-104G**	**5St 102Gr**	**loss of control in bad weather conditions at Senigallia near Ancona, pilot was injured**
11.01.1966	**6574**	**F-104G**	**9St 10Gr**	**heavy landing in bad weather condition, pilot was injured**
25.01.1966	**6548**	**F-104G**	**4St 9Gr**	**engine failure near Accumoli, Rieti, pilot ejected safely**
19.04.1966	**6584**	**F-104G**	**5St 102Gr**	**ground contact after flight test at Grosseto airport (CFIT), pilot was killed**
06.07.1966	**6521**	**F-104G**	**6St 154Gr**	**mid-air collision with MM6650 near Mantova, pilot was killed**
06.07.1966	**6650**	**RF-104G**	**6St 154Gr**	**mid-air collision with MM6521 near Mantova, pilot was killed**
31.08.1966	**6636**	**RF-104G**	**5St 102Gr**	**ground contact during recovery in a gunnery event at Maniago range due to bad weather, pilot was killed**
05.06.1967	**6538**	**F-104G**	**9St 10Gr**	**heavy damaged in open field after take-off abort and barrier arrestment failure at Cameri, pilot was safe**

03.07.1967	6530	F-104G	5St 102Gr	heavy damaged in open field after take-off abort and barrier arrestment failure, pilot was safe
11.07.1967	6534	F-104G	6St 154Gr	crashed into mountain (CFIT), pilot was killed
03.11.1967	6537	F-104G	6St 154Gr	heavy damaged in open field after take-off abort near Borgosatollo Brescia, pilot was safe
07.02.1968	6554	F-104G	53St 21Gr	mid-air collision during night intercept mission with MM6562, pilot ejected safely
07.02.1968	6562	F-104G	53St 21Gr	mid-air collision during night intercept mission with MM6554, pilot ejected but died
08.05.1968	6519	F-104G	6St 154Gr	crashed into Adriatic sea, Tremiti islands, cause unknown, pilot was killed
09.06.1968	6592	F-104G	53St 21Gr	after mid-air collision with MM6554 and MM6562, repaired, but w/o that date
01.07.1968	6566	F-104G	4St 9Gr	mid-air collision, pilot ejected safely
18.07.1968	6570	F-104G	9St 10Gr	ground contact for unknown reason (CFIT), pilot was killed
10.02.1969	54236	TF-104G	20 Gr Auto	during the mission the port tiptank separated from the wing and severely damaged stabilizer and rudder on impact. The aircraft was uncontrollable and crashed; one pilot ejected, one pilot was killed
02.06.1969	6543	F-104G	5St 102Gr	mid-air collision with MM6581; air parade Festa della Repubblica, pilot killed
02.06.1969	6581	F-104G	5St 102Gr	mid-air collision with MM6543; air parade Festa della Repubblica, pilot injured
25.07.1969	6610	F-104G	6St 154Gr	crashed at Ghedi AB after loss of thrust on take-off, pilot injured
29.07.1969	6512	F-104G	6St 154Gr	loss of thrust in flight, pilot ejected but injured. Aircraft on temporary loan to 20 Gr
11.08.1969	6506	F-104G	5St 102Gr	crashed into the ground during low level navigation, pilot was killed
29.09.1969	6549	F-104G	6St 154Gr	engine failure, most probable oil system failure, pilot ejected safely
16.02.1970	6557	F-104G	9St 10Gr	lightning strike during GCA into Grazzanise AB, pilot ejected but died
28.04.1970	6569	F-104G	9St 10Gr	engine flame out, pilot ejected safely
04.06.1970	6587	F-104G	5St 102Gr	caught on fire during engine test run at Rimini AB, specialist injured
14.09.1970	6725	F-104S	36St 156Gr	loss control after APC problems. Pilot ejected. 1st ejection with F-104S
12.10.1970	6580	F-104G	FIAT	engine loss of thrust in flight, pilot ejected
21.10.1970	6539	F-104G	6St 154Gr	mid air collision with wingman during formation change position
19.04.1971	6743	F-104S	36St 156Gr	Total hydraulic failure near Altamura. Pilot ejected safely
15.07.1971	6715	F-104S	4St 9Gr	Loss of aircraft control during landing at Grosseto AB. Pilot killed
08.09.1971	6536	F-104G	6St 154Gr	mid air collision during formation rejoin, over Maniago range, with MM6560. Pilot killed
08.09.1971	6560	F-104G	6St 154Gr	mid air collision during formation rejoin, over Maniago range, with MM6536. Pilot ejected safely. 1st ejection with Martin Baker Mk.IQ-7A
01.10.1971	6766	F-104S	Aeritalia	Engine flame out. Aeritalia pilot at his 2nd ejection.
20.10.1971	6712	F-104S	51St 22Gr	Water contact for unknown reason 5NM south of Caorle, east of Venice. Pilot was killed
20.10.1971	6724	F-104S	51St 22Gr	Water contact for unknown reason 5NM south of Caorle, east of Venice. Pilot was killed
22.05.1972	6658	RF-104G/ F-104S	RSV	loss of aircraft control due to uncontrolled movements, pilot ejected safely. F-104S prototype
14.02.1973	6779	F-104S	50St 155Gr	Hit mountain ridge in bad weather conditions At Rivergaro, Piacenza. Pilot was killed
14.02.1973	6790	F-104S	50St 155Gr	Hit mountain ridge in bad weather conditions At Rivergaro, Piacenza. Pilot was killed
01.03.1973	6541	F-104G	6St 154Gr	loss of aircraft control (APC malfunction?), pilot injured
21.03.1973	6515	F-104G	6St 154Gr	Loss of aircraft control during simulated ground attack with Alpen troops due to kicker activation at Alesso di Trasaghis, Udine. Pilot was killed
13.04.1973	6755	F-104S	36St 156Gr	Loss of aircraft control during simulated ground attack near Altamura, Bari. Pilot killed
26.06.1973	6591	F-104G	6St 154Gr	ground contact for unknown reason, pilot was injured
18.09.1973	6738	F-104S	53St 21Gr	Water contact in the sea near Trapani Birgi. Pilot was killed
18.09.1973	6746	F-104S	36St 156Gr	Flame out after running out of fuel. Pilot ejected safely
26.09.1973	6813	F-104S	5St 23Gr	Water contact in bad weather conditions for unknown reasons: most likely disorientation! Pilot was killed. The aircraft was the first F-104S for 23 Gruppo and handed over to the squadron on March 9, 1973.
12.12.1973	6638	RF-104G	3St 28Gr	caught fire on ground at Grazzanise AB during double regulator check for tip tank pressurization, pilot was injured
25.04.1974	6753	F-104S	36St 156Gr	Caught fire on ground during arming crew maintenance work checking the "Auto Drop" system.
07.05.1974	6709	F-104S	53St 21Gr	Ground contact at Granozzo, Novara, during a Tac Eval. Pilot was killed.
13.05.1974	6707	F-104S	51St 22Gr	Engine flame out at Porcellengo di Treviso. Pilot ejected safely.
20.05.1974	6777	F-104S	51St 22Gr	In short final, during a night formation landing, maybe he got into leaders jet wash and then crashed inside Istrana AB. Pilot killed
06.06.1974	6801	F-104S	36St 12Gr	Loss of aircraft control after uncontrolled roll movements in landing at Gioia del Colle AB. Pilot

				was killed.
19.09.1974	6799	F-104S	36St 156Gr	Crashed into the mountain near Matera after broken control linkage. Pilot injured
20.09.1974	54252	TF-104G	20Gr Auto.	lost south of Peretola Airport, Florence. Both pilots were killed.
15.02.1975	6743	F-104S	36St 156Gr	Hit the ground near Meta Ponto (Province of Potenza) after a stall, pilot was injured. 3rd ejection for this pilot, the1st with an F-84F the 2nd with MM6746
15.03.1975	6829	F-104S	5St 102Gr	Hit mountain during recovery in bad weather conditions. Pilot was killed.
20.05.1975	54227	TF-104G	20Gr Auto	Forward flap actuator failure. Both pilots ejected safely.
13.06.1975	6834	F-104S	51St 155Gr	Too late for escape maneuver in bad weather conditions, the aircraft hit the mountain at Pietra Bianca di Farindola, Pescara. Pilot was killed.
16.07.1975	6832	F-104S	5St 102Gr	Crashed, near Gorgona island, into the Tirrenian sea during exercise with Italian Navy. Pilot killed
09.09.1975	6644	RF-104G	3St 28Gr	Engine loss of thrust in flight, pilot ejected near Villafranca AB
25.09.1975	6508	F-104G	6St 154Gr	struck mountain in bad weather conditions 15 NM south of Bitburg near Wenzelberg (Germany). No proper flight technique by the formation leader in not easy meteorological and environmental conditions. Pilot was killed.
25.09.1975	6516	F-104G	6St 154Gr	struck mountain in bad weather conditions 15 NM south of Bitburg near Wenzelberg (Germany). No proper flight technique by the formation leader in not easy meteorological and environmental conditions. Pilot was killed.
25.09.1975	6523	F-104G	6St 154Gr	struck mountain in bad weather conditions 15 NM south of Bitburg near Wenzelberg (Germany). No proper flight technique by the formation leader in not easy meteorological and environmental conditions. Pilot was killed.
25.09.1975	6575	F-104G	6St 154Gr	struck mountain in bad weather conditions 15 NM south of Bitburg near Wenzelberg (Germany). No proper flight technique by the formation leader in not easy meteorological and environmental conditions, pilot was killed
22.03.1976	6556	F-104G	6St 154Gr	ground contact near Castiglione di Cervia, for unknown reasons, maybe slight illness, maybe spatial disorientation, pilot was killed
08.04.1976	54234	TF-104G	20Gr Auto	crashed into mountain at Colle Trinità near Perugia, both pilots killed
21.06.1976	6526	F-104G	3St 28Gr	Crashed into ground at Lendinara, Rovigo. Pilot killed
03.08.1976	6874	F-104S	36St 12Gr	Crashed into ground for unknown causes near Matera. Pilot killed
06.10.1976	6728	F-104S	4St 9Gr	violent uncontrolled rolls, crashed into sea off coast Carbonifera, Livorno. Pilot ejected
14.12.1976	6503	F-104G	6St 154Gr	flame out during gunnery event at Capo Frasca range. Pilot ejected
23.05.1977	6573	F-104G	3St 132Gr	autopilot failure with pusher activation at Alpo, Villafranca, pilot injured
29.08.1977	6585	F-104G	3St 18Gr	stiff flight controls after pusher activation at Mirandola, Modena, pilot injured
25.09.1977	6751	F-104S	51St 155Gr	caught fire in open field, in Vedelago countryside, after take-off abort due to failure to rotate, pilot ejected but badly injured
29.11.1977	6877	F-104S	4St 9Gr	Loss of aircraft control at Monte Solenne, Spoleto. Pilot was injured
28.06.1978	6645	RF-104G	3St 28Gr	flame out due a mechanical broken linkage at Casalmaggiore, Parma, pilot was injured
30.06.1978	6871	F-104S	53St 21Gr	Hit mountain for unknown causes. Colle della Ciabra, Cuneo. Pilot was killed
03.08.1978	6907	F-104S	36St 156Gr	water contact during exercise with Italian Navy, pilot was killed
24.11.1978	6773	F-104S	36St 12Gr	Loss of aircraft control during ACM at Stigliano, Materna. Pilot injured
04.12.1978	6931	F-104S	51St Gr22	Heavy damaged while landing at alternate airfield Brindisi. Touch down short of runway in bad weather conditions. Pilot safe.
18.01.1979	6803	F-104S	53St 21Gr	Hit ground due to sudden pilot collapse near Castelletto di Branduzzo, Pavia. Pilot killed
01.02.1979	6783	F-104S	9St 10Gr	Loss of aircraft control during fuel transfer at Terracina, Roma. Pilot ejected
04.03.1979	6927	F-104S	5St 23Gr	Crashed near Sigonella AB during landing pattern, possible loss of control due to low speed during turn. Pilot was killed
14.06.1979	6571	F-104G	6St 154Gr	heavy damaged in open field after take-off abort at Ghedi AB, pilot eject
11.07.1979	6553	F-104G	3St 132Gr	APC activation (kicker) during gunnery event at Capo Frasca range, pilot killed
19.11.1979	54259	TF-104G	20 Gr Auto	approaching Grosseto AB loss altitude and crashed in the Tirrenian sea, probably spatial disorientation in poor weather condition. Both pilots killed
18.01.1980	6510	F-104G	6St 154Gr	flame out during gunnery event at Capo Frasca range. Pilot ejected
27.05.1980	6648	F-104G	3St 132Gr	ground contact 14 min after take off due to quick weather deterioration at Bordella di San Benedetto, Ancona, pilot was killed
11.07.1980	6723	F-104S	53St 21Gr	Loss of aircraft control during ACM at Robilanate, Cuneo. Pilot was injured.
15.09.1980	54231	TF-104G	20Gr Auto	Caught fire during take off after too early gear retraction, aircraft damaged beyond repair, both pilots were safe.

05.10.1981	6517	F-104G	6St 154Gr	crashed during recovery maneuver at low altitude in a gunnery event at Maniago range. Pilot was killed.
09.02.1982	6780	F-104S	36St 156Gr	Ground contact under GCA control 6 KM before Gioia del Colle AB in bad weather conditions, causes unknown. Pilot killed
01.04.1982	6572	F-104G	6St 154Gr	hit electric power pylon during a low level, high speed pass at Ghedi, crashed inside Ghedi AB, pilot made his 2nd ejection
10.05.1982	6718	F-104S	36St 12Gr	heavy landing, aircraft presumably damaged beyond repair; pilot was safe
14.05.1982	6757	F-104S	5St 102Gr	after a gunnery session at Maniago range, approaching Rimini AB, left the formation and crashed near Comacchio; pilot was killed
02.06.1982	6917	F-104S	36St 156Gr	broken forward flap linkage during gunnery mission at Punta della Contessa, Brindisi; pilot was killed
02.07.1982	6582	F-104G	3St 28Gr	engine flame out approaching Villafranca AB at Bionde di Salizzole, pilot ejected but died
03.08.1982	6765	F-104S	53St 21Gr	Crashed into the ground at high sink rate due to bad weather conditions. Pilot was killed.
17.02.1983	6911	F-104S	51St 155Gr	Crashed into the ground after hitting power line cables at Caerano San Marco, Treviso. 5.000 Martin Baker ejection
15.09.1983	6837	F-104S	51St 155Gr	Afterburner blow-out on take-off from Istrana, aircraft crashed into the approach lights. Pilot was safe.
22.12.1983	6711	F-104S	53St 21Gr	Left gear damaged by frozen snowdrift during take-off from Cameri AB, the hydraulic leak light illuminated on the aircraft. Pilot ejected but was injured
27.01.1984	6752	F-104S	51St 155Gr	Impact with mountain ridge in bad weather conditions. Monte Molinatico, Parma. Pilot was killed.
29.02.1984	6531	F-104G	3St 28Gr	ground contact maybe due to spatial disorientation in bad weather conditions at Mezzolara di Budrio. Pilot killed
10.05.1984	6811	F-104S	9St 10Gr	Impact with mountain during night flight. Monte Viola near Formia. Pilot was killed
15.06.1984	6745	F-104S	51St 155Gr	Engine flame out during gunnery mission at Capo Frasca range. Pilot ejected safely
30.10.1984	6793	F-104S	53St 21Gr	Caught fire on ground during 5 finger check due to a double regulator malfunction in the internal tank. Pilot badly injured and died in the hospital few hours later.
26.11.1985	6841	F-104S	5St 102Gr	Crashed in the Adriatic Sea 2 NM from Torino di Sangro. Pilot was killed
10.01.1986	6823	F-104S	53St 21Gr	Touch down 900 m before runway end at Cameri AB during GCA in bad weather condition, pilot ejected
28.01.1986	6646	RF-104G	3St 28Gr	during formation rejoin, in left turn, water impact in Marano lagoon, pilot was killed
18.03.1986	6924	F-104S	5St 102Gr	loss of electrical system and engine flame out after cavitation of the boost pump during test flight, pilot ejected; several casualties on the ground
16.06.1986	6928	F-104S	36St 12Gr	loss engine thrust due to compressor stall approaching Gioia del Colle AB. Pilot ejected but was injured
04.08.1986	6586	F-104G	3St 132Gr	altitude loss due to APC failure near Bernbach, Germany, pilot ejected
22.08.1986	6706	F-104S	4St 9Gr	Ground contact after looping at Pietralunga, Perugia (CFIT). Pilot was killed
21.05.1987	54228	TF-104G	4St 20Gr	Damaged in belly landing at Grosseto AB after Main Landing Gear malfunction. Pilots both ejected safely
29.05.1987	6710	F-104S	36St 12Gr	Water impact at very high sink rate during ACM mission in Capo Frasca, Sardinia. Pilot and aircraft missing.
31.05.1988	54229	TF-104G	4St 20Gr	Ground impact after a barrel roll at Trapani AB. Both (pilot and photographer) killed.
27.07.1988	6608	RF-104G	3St 132Gr	impact with the VOR antenna in the runway overrun on take-off from Villafranca AB, aircraft did not lift off, pilot was killed
05.09.1988	6933	F-104ASA	5St 23Gr	Engine failure just after take off from Rimini AB. Pilot ejected safely.
19.10.1988	54557	TF-104G	4St 20Gr	very hard landing, collapsing the landing gear and damaged (non coded) at Bitburg AB, Germany (ex GAF aircraft)
13.06.1989	6846	F-104ASA	37St 18Gr	Water contact in the landing pattern at Trapani AB. Pilot was killed
10.10.1989	6702	F-104S	53St 21Gr	Loss of thrust and crashed on approach lights. Pilot ejected but died. First F-104S delivered to AMI
27.12.1989	6886	F-104ASA	5St 102Gr	Mountain ridge impact in bad weather conditions. Pilot killed
27.12.1989	6919	F-104ASA	5St 102Gr	Mountain ridge impact in bad weather conditions. Pilot was killed
05.07.1990	6729	F-104S	4St 9Gr	Ground impact after take off from Sigonella AB. Pilot was killed.
08.09.1990	6748	F-104ASA	37St 18Gr	Ground impact during navigation flight, possible vertigo or disorientation. Pilot killed
23.04.1991	6736	F-104ASA	4St 9Gr	flame out in storm during GCA approach at Grosseto AB, pilot ejected
06.09.1991	54255	TF-104G	4St 20Gr	Engine failure after compressor stall. Both pilots ejected safely.
07.11.1991	6708	F-104ASA	5St 23Gr	Mid air collision with MM6806 at Imola. Pilot ejected
07.11.1991	6806	F-104ASA	5St 23Gr	Mid air collision with MM6708 at Imola. Pilot ejected
16.01.1992	6839	F-104ASA	4St 9Gr	Water impact during exercise with 2 other F-104s, near Pianosa island. Pilot killed
04.05.1993	6835	F-104ASA	36St 12Gr	heavy damaged left wing during barrier engage at Gioia del Colle AB, written off later because the aircraft was damaged beyond repair. Pilot ok.
06.05.1993	6869	F-104ASA	4St 9Gr	AB blow out due to broken linkage during take off from Grosseto AB. Pilot ejected but was killed.

19.01.1994	6727	F-104ASA	9St 10Gr	Mountain ridge impact at Monte Giano, Rieti. Pilot was killed
15.02.1995	6878	F-104ASA	53St 21Gr	Pitch up due to APC failure near Cuneo; pilot ejected safely
20.06.1995	54256	TF-104G	4St 20Gr	crashed into sea south of Montechristo near Grosseto in bad visibility during a low level flight from Decimomannu; single pilot was killed
13.02.1996	6843	F-104ASA	4St 9Gr	Loss of aircraft control during landing at Grosseto AB, pilot ejected but aircraft flew for few kilometers and then crashed in Grosseto outskirts
12.11.1996	6815	F-104ASA	37St 18Gr	water impact when approaching Trapani AB, the aircraft stalled and turned upside down. Pilot was killed.
28.01.1997	6730	F-104ASA	9St 10Gr	water impact (CFIT) after an exercise with Italian Navy, pilot ejected safely
15.04.1997	6818	F-104ASA	37St 18Gr	Water impact (CFIT) near Pantelleria island during training with 2 other F-104 from Trapani, maybe he encountered a pitch-up. Pilot ejected but could not be found, pilot body was not recovered and is still missing.
21.04.1997	54257	TF-104G	4St 20Gr	Severely damaged during touch and go. Aircraft damaged beyond repair. Both pilots safe
04.11.1998	6944	F-104ASAM	37St 18Gr	Lost 5 km from Trápani near the island of Maréttimo. Flying with three other F-104s from Trápani, the engine lost power due to engine flame out. Pilot had no other option than to eject. First F-104s ASA-M accident
18.01.1999	6938	F-104ASAM	5St 23Gr	main Landing Gear structure collapsed after take off from Trápani-Birgi AB. The aircraft came down 13 kilometers from the cost between Marsala and Favignana. After take-off from Trápani-Birgi, the main landing gear failed to retract and the pilot was forced to make a controlled ejection over the sea, pilot ejected safely. Pilot at his 2nd ejection
22.08.2000	54558	TF-104GM	4St 20Gr	Main Landing Gear structure severely damaged after touch and go at Grosseto AB, no landing possible, controlled ejection over the sea, both pilots ejected safely.
05.10.2000	6775	F-104ASAM	37St 18Gr	Crashed near Castelvetrano, some 20 kilometers east of Mazara del Vallo. The Starfighter was part of a four ship formation flying from Trápani, when the engine flamed out. Pilot ejected safely, one person on the ground was killed by debris.
25.11.2001	54233	TF-104G	RSV	heavy damaged after roof collapse during a storm at Pratica di Mare AB, withdrawn from use. Last flying not "M" modified TF-104G
04.03.2002	6929	F-104ASAM	4St 9Gr	Pilot reported an on-board fire after take off from Grosseto AB and had to abandon his aircraft. Crashed into the hills between Buriano and Vetulónia. Pilot ejected safely.
02.05.2002	6778	F-104ASAM	9St 10Gr	crashed on the runway of Leeuwarden AB, Netherlands because of bad visibility (low cloud and some light rain) and the fact that he flew its approach to high. The tail touched the runway first due to high sink rate, the aircraft bounced and broke up in 3 parts. Pilot luckily survived, though badly injured.

RCAF F-104 Accidents (Partial)

	Date	Version	Operator	Severity	Probable Cause & Remarks
1.	25th November 1961	CF-104	RCAF	Non-Fatal	Automatic pitch system. Likely rigging problem.
2.	22nd May 1962	CF-104	RCAF	Non-Fatal	During takeoff, the canopy opened - Loss of thrust due to nozzle pump failure
3.	10th August 1962	CF-104	RCAF	Fatal	Loss of thrust during touch-and-go – Failed Ejection
4.	4th September 1962	CF-104	RCAF	Non-Fatal	Hit tree on final approach
5.	27th May 1963	CF-104	RCAF	F/L L.A. Tapp	Engine flamed out on an initial acceptance flight
6.	19th June 1963	CF-104	RCAF	F/L Wallis Glen Hollingshead ejected at too low altitude and killed	Aircraft struck ground after takeoff, probably due to open canopy
7.	11th September 1963	CF-104	RCAF	F/L Donald Oswald Schneider ejected at too low altitude and killed	Engine Nozzle problems
8.	23rd October 1963	CF-104	RCAF	Flt. Lt. H.R. Venus	Engine fire on final approach
9.	1st November 1963	CF-104	RCAF	F/t. Lt. C. W. Gehman	Failure of main fuel control unit
10.	10th January 1964	CF-104	RCAF	F/0 B. L. Smith	Mid-Air collision in formation
11.	27th January 1964	CF-104	RCAF	Flt. Lt. L. G. Van Vliet	Engine nozzle failure at low level

12.	5th March 1964	CF-104	RCAF	F/0 A. Doran	Engine failure on low level bombing run, probably due to birdstrike
13.	1st May 1964	CF-104	RCAF	F/L D. E Wilson	Nozzle failure on GCA approach
14.	11th May 1964	CF-104	RCAF	Flt. Lt. L. J. Bentham	Disconnect of rudder linkage during flight
15.	25th June 1964	CF-104	RCAF	F/t. Lt. W. G. Baker	Possible bird strike compressor stall on low level flight
16.	27th October 1964	CF-104	RCAF	Sqn. Ldr. J. L. Frazer.	Engine failure due to birdstrike
17.	16th November 1964	CF-104	RCAF	Flt. Lt. Harry R. Stroud	Engine failure due to inadequate maintenance
18.	24th February 1965	CF-104	RCAF	S/L R.W. Spencer	Engine fire during flight.
19.	4th May 1965	CF-104	RCAF	F/L R.C. Beehler	Engine fire during flight.
20.	9th June 1965	CF-104	RCAF	Flg. Off. G.W. Sanderson	Pilot lost control due to undetermined technical malfunction on final approach
21.	11th June 1965	CF-104	RCAF	F/0 D.M. Caldwell	Compressor stall shortly after takeoff
22.	5th July 1965	CF-104	RCAF	Flt. Lt. D. C. K. Thorn	Engine failure during flight
23.	9th August 1965	CF-104	RCAF	F/0 Don Scott	Engine fire during flight.
24.	13th August 1965	CF-104	RCAF	Flt. Lt. E. A. Seitz	Engine failure during flight
25.	16th September 1965	CF-104D	RCAF	Flt Lt J E Greidanaus Capt C F Summers	Bird strike-engine failure
26.	16th September 1965	CF-104	RCAF	F/L Kenneth "Ken" D. Castle	Birdstrike. Engine failure due to compressor disintegration at high speed
27.	21st March 1966	CF-104	RCAF	F/L J. M. Ayres	Severe compressor stall due to birdstrike
28.	12th October 1966	CF-104	RCAF	F/L R.R. Challoner	Engine failure due to birdstrike
29.	28th October 1966	CF-104	RCAF	F/0 Rob Zemek	Aircraft pitched up during handling exercise
30.	30th March 1967	CF-104	RCAF	F/t. Lt. H.J. Rowe	Engine failure due to birdstrike immediately after takeoff
31.	21st May 1967	CF-104	RCAF	S/L M. R. MacGregor ejected on take-off	Thrust loss on takeoff
32.	20th July 1967	CF-104	RCAF	F/0 Robin John "Rob" Zemek ejected but sustained fatal injuries due to seat malfunction	Aircraft pitched up due to pilot disorientation Rastatt, Germany
33.	18th July 1967	CF-104	RCAF	Flt. Lt. G.R.J. "Sky" King	Compressor stall due to birdstrike
34.	3rd August 1967	CF-104	RCAF	F/0 L. B. Mealing	Control loss due to hydraulic system contamination
35.	4th Nov 1967	CF-104	RCAF	S/L J. E. Greatrix	Engine failure during flight
36.	27th May 1968	CF-104D	RCAF	Capt J. M. Denard	In-flight engine failure
37.	Wednesday 19th June 1968 19:13	CF-104	RCAF	Captain Robert James Swanston ejected with aircraft rolling at approx. 275 ft but with insufficient time	Approach after completing a low-level cross country navigation mission. Aircraft went out of control while in the circuit for landing Baden Soellingen, Germany

				to effect parachute deployment	
38.	15th July 1968	CF-104	RCAF	Capt. V. F. Gerden	Oil system malfunction during flight
39.	24th Sep 1968	CF-104	RCAF	Capt. D. Macintosh	Aircraft pitched up while avoiding another aircraft
40.	15th Nov 1968	CF-104	RCAF	Lt. J. A. M. Lemire	Engine failure due to birdstrike
41.	14th January 1969	CF-104	RCAF	Lieutenant R. B. Kaiser Victoria, British Columbia killed no ejection attempted	Local, night low-level navigation training mission. Crashed on Primrose Lake Weapons Testing Range, in a shallow, steeply banked descent
42.	2nd Apr 1969	CF-104	RCAF	Maj. W. L. "Bill" Worthy	Engine failure due to foreign object damage
43.	25th Apr 1969	CF-104	RCAF	Capt. R. E. White	Severe cockpit damage after birdstrike
44.	9th Jul 1969	CF-104	RCAF	Capt. J.R. Dunlop	In-flight fire due to foreign object damage
45.	25th Jul 1969	CF-104	RCAF	Lt. G. P. Ferris	Mid-air collision on training flight
46.	19th Aug 1969	CF-104	RCAF	Capt. G. F. Ball	Engine failure due to birdstrike
47.	5th Sep 1969	CF-104	RCAF	Capt. K. J. Chatfield	Loss of control during formation takeoff
48.	6th Nov 1969	CF-104	RCAF	Fatal	Aircraft struck top of hill on low level mission – Unsucessful Ejection
49.	14th Apr 1970	CF-104	RCAF	Capt. J. M. Hivon	Mid-air collision in cloud on instrument approach
50.	14th Apr 1970	CF-104	RCAF	Maj. M. D. Thorn	Mid-air collision in cloud on instrument approach
51.	27th Apr 1970	CF-104	RCAF	Capt. D. R. Graham (or is it G. R. Graham??)	Multiple compressor stalls at high level due to engine foreign object damage
52.	17th June 1970	CF-104	RCAF	Capt. D. V. Koski	Aircraft struck trees on practice weapon delivery
53.	7th October 1970	CF-104D	RCAF	Maj W Bain Captain L. A. O'Brien	In-flight engine failure
54.	25th March 1971	CF-104	RCAF	Capt. R. A. Heston	Structural breakup due to inadvertent overstress during air combat manoeuvring
55.	10th June 1971	CF-104	RCAF	Capt. J. M. Westrop	Control problems due to failure of #2 hydraulic system.
56.	16th June 1971	CF-104	RCAF	Maj. M. I. Chesser	Mid-air collision shortly after takeoff
57.	23rd July 1971	CF-104	RCAF	Lt. D. J. Burroughs	Severe compressor stall in transit to an exercise area.
58.	27th October 1971	CF-104D	RCAF	Capt Bruce O. Lundquist Capt P. M. Davis	Engine failure (FOD and fire)
59.	4th May 1973	CF-104	RCAF	Capt. John B. Croll ejected	Aircraft hit trees on practice weapons delivery
60.	10th May 1973	CF-104	RCAF	Capt. Paul J. Rackham ejected, but too late for parachute deployment	Aircraft pitched up in landing pattern
61.	17th August 1973	CF-104	RCAF	Capt. J. E. McGillivray	Aircraft struck trees on a practice tactical weapons delivery
62.	11th March 1974	CF-104	RCAF	Maj. W. H. Blatter	In-flight fire while on radar final
63.	19th Mar 1974	CF-104	RCAF	Maj. M. D. Johnson	Compressor stall due to gun malfunction in fligh
64.	27th May 1974	CF-104	RCAF	Maj. E. S. Andrichuk	Compressor stall at low level due to bird strike

65.	7th November 1974	CF-104D	RCAF	Capt G. R. Todd Lt M. G. Abbott	Test flight - engine failure due to fod
66.	11th December 1974	CF-104	RCAF	Capt. F. G. Youngson	Massive in-flight control restriction due to unidentified foreign object damage
67.	9th September 1975	CF-104	RCAF	Capt. J. E. McGillivray second ejection	Engine fire on takeoff
68.	7th March 1978	CF-104	RCAF	Capt. B. M. Robinson	Engine failure due to series of compressor stalls
69.	18th August 1978	CF-104	RCAF	Capt. R. Bollinger	Engine failure due to birdstrike
70.	24th June 1980	CF-104D	RCAF	Capt H Riedel (Luftwaffe)	Bird strike-engine failure
71.	27th August 1980	CF-104	RCAF	Maj. R. W. Porter	Loss of control due to flap structural break-up on practice bomb delivery
72.	27th November 1980	CF-104	RCAF	Capt. Ralph Harrison	Explosion/Fire in flight caused by Personal - Maintenance - Inattention and as a second factor: Management - National Defence Headquarters - Information
73.	16th March 1981	CF-104D	RCAF	Capt L. A. Sianchuk Lt H. Raffel	Bird strike-compressor stall
74.	9th June 1981	CF-104	RCAF	Lt. K. G. Cranfieldsee also 4th June 1982	Aircraft struck trees on simulated tactical delivery
75.	11th December 1981	CF-104	RCAF	Maj. G. W. Nicks	Aircraft struck frozen lake surface on low level tactical mission
76.	30th April 1982	CF-104	RCAF	Capt. Dave Ghyselincks	Loss of control during air combat training
77.	4th June 1982	CF-104	RCAF	Capt. K. G. Cranfield see also 9th June 1981	In-flight fire due to improper maintenance
78.	29th July 1982	CF-104	RCAF	Col. J. L. Frazer	Mid-air collision while on training mission
79.	10th January 1983	CF-104	RCAF	Capt. Tom F. Klassen	Engine failure due to foreign object damage
80.	22nd May 1983	CF-104	RCAF	Non-Fatal	Aircraft departed controlled flight during an air display
81.	16th June 1983	CF-104	RCAF	Capt G.W. Bayles	Compressor stall due to ricochet during a strafe pass

http://www.ejection-history.org.uk/Aircraft_by_Type/Canadian_CF-104.htm

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Attachment 6 – Glossary and Abbreviations

°	Degrees
#	Pounds
AAIB	Aviation Accident Investigation Board (UK)
A&P	Airframe & Powerplant (Mechanic)
AAM	Air-to-Air Missile
ABO	Aviator's Breathing Oxygen
AC	Advisory Circular
ACES	Modern Ejection Seat Fitted to many US Combat Aircraft
ACMI	Air Combat Maneuvering Instrumentation
AD	Airworthiness Directive
ADM	Aeronautical Decision Making
AFM	Airplane Flight Manual
AFS	Flight Standards
AGC	FAA's Office of the Chief Counsel
AIM	Air Intercept Missile
AIP	Aircraft Inspection Program
AIR-200	FAA – Production & Airworthiness Division
AIR-230	FAA – Airworthiness Branch
AloS	Acceptable Level of Safety
ALQ	ECM Pod(s), i.e., ALQ-167
AOA	Angle of Attack
AND	Aircraft Not Destroyed
AP	Air Publication
ARB	Airworthiness Review Board (UK CAA)
ASI	Aviation Safety Inspector
ATC	Air Traffic Control
ATF	Bureau of Alcohol, Tobacco, Firearms, and Explosives
Avon	Hunter Rolls-Royce Engine
AVS	FAA Aviation Safety (Line of Business Designator)
Avpin	Liquid Fuel Starter System Installed in the Hunter
Boscombe Down	RAF Flight Test Facility
CAA	Civil Aviation Authority
CAR	Civil Air Regulations
CAS	Close Air Support
CFIT	Control Flight Into Terrain
CFR	Code of Federal Regulations
CG (c.g.)	Center of Gravity
CJAA	Classic Jet Aircraft Association
Class A	Accident Classification Used by USAF and U.S. Navy
COS	Continued Operational Safety
CP	Center of Pressure
DAR	Designated Airworthiness Representative
DER	Designated Engineering Representative
DHS	Department of Homeland Security

DOD	Department of Defense
EAA	Experimental Aircraft Association
ECM	Electronic Counter Measures
EEJ	Experimental Exhibition Jets
EHSI	Electronic Horizontal Situation Indicator
EO	Engineering Order
EPR	Engine Pressure Ratio
FAA	Federal Aviation Administration
FBO	Fixed Base Operator
FL	Flight Level
FOD	Foreign Object Damage
Form 700	Aircraft Record (RAF)
Form 781	Aircraft Flight Data Record
FSIMS	Flight Standards Information Management System
FSDO	Flights Standards District Office
Ft	Feet
GA	General Aviation
HB	Swiss Registration
Hg	Mercury
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
IMC	Instrument Meteorological Conditions
INM	Indicated Mach Number
INOP	Inoperative
IRAN	Inspect and Repair as Necessary
JATO	Jet Assisted Take-Off (aka RATO – Rocket Assisted Take-Off)
JH	Jet Heritage
JP-4/JP-5	Military Designations for Jet Fuels
LABS	Low Altitude Bombing System
Lb.	Pounds
LOC	Loss of Control
LOX	Liquid Oxygen
LTO	Letter to Operators
Mach	Speed of Sound
Martin Baker	Manufacturer of Ejection Seats Fitted to the Hunter
MEL	Minimum Equipment List
MIDO	Manufacturing Inspection District Office
mm	Millimeters
Mod	Modification to Hunter Aircraft by Hawker (Manufacturer) and/or RAF
MTBF	Mean Time Between Failure
MTBO	Mean Time Between Overhauls
NACES	Modern Ejection Seat Fitted to Many U.S. Navy Aircraft
NATO	North Atlantic Treaty Organization
NDI	Non-Destructive Inspection
NDT	Non-Destructive Testing
NTSB	National Transportation Safety Board
O_2	Oxygen
OEM	Original Equipment Manufacturer

ORM	Operational Risk Management
PAO	Public Aircraft Operations
PFCU	Powered Flight Control Unit
PIC	Pilot in Command
Pilot Notes (PN)	RAF Designation for Aircraft Flight Manual
PIO	Pilot Induced Oscillations
PPH	Pound per Hour
Psi	Pounds per Square Inch
PSP	Personal Survival Pack
QRB	Quick Release Box
R&D	Research and Development
RAT	Ram Air Turbine
RCR	Runway Condition Reading
RM	Risk Management
RN	Royal Navy
RPZ	Runway Protection Zone
RSA	Runway Safety Area
RSC	Runway Surface Condition
RSAF	Republic of Singapore Air Force
MA-1A	USAF Arresting Barrier
MAF	Maintenance Action Form (U.S. Navy)
Major Service	RAF Equivalent of U.S. Depot Level Inspection
Mk.	Mark
MRO	Maintenance, Repair, and Overhaul
NAS	National Airspace System
SAF	Swiss Air Force
SMS	Safety Management Systems
SOAP	Spectrometric Oil Analysis Program
SRM	Single Pilot Resource Management
T7 & T8	Two Seat version of the Hunter
TBO	Time Between Overhauls
TO	Take-Off
TSA	Transportation Safety Administration
UHF	Ultra High Frequency
UK	United Kingdom
USAF	United States Air Force
USN	United States Navy
VFR	Visual Flight Rules
VT	US Navy Training Squadron
W&B	Weight and Balance
ZU-BEX	South African Civil Registration for a Lightning T5

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U.S. AIR FORCE